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CONTENTS

FEATURES

SIGMA	1
Multicast Back Bone	7
OMNIWeb	12
Imaging Radar Page	16
Video of the Moon	18
Education on the Internet	23
Automating Archival	27
Space Physics Meeting	29
Supernova/Supercomputer	30
Data Restoration	42

DEPARTMENTS

Calendar	6
PDS (Planetary)	8
NSI (Networking)	19
ADS (Astrophysics)	25
PO.DAAC	33
NAIF	35
Accomplishments	40

SIGMA: An Intelligent Visual Programming Environment for Scientific Modeling

Richard M. Keller, Recom Technologies, Computational Sciences Division, Ames Research Center

Within both NASA and the scientific community at large, computer models are playing an increasingly important role in the conduct of science today. Scientists construct software models to analyze data, to validate theories, and to predict a whole variety of phenomena. Developing a new scientific model is a time-intensive and painstaking process. Usually, scientific models are implemented using a general-purpose computer programming language, such as FORTRAN. Implementation can involve writing large and complex programs that access multiple data sets and utilize numerous different statistical and numerical processing packages. Software development time for large scientific models can take on the order of many months, to years, of effort.

Although considerable resources must be expended to build a scientific model, for a variety of reasons it may be difficult to share the completed model with colleagues in the scientific community. Model sharing is highly desirable because it enables researchers to conserve resources and build upon each others' efforts in a synergistic fashion. Unfortunately, modeling code is typically low level and idiosyncratic, and it may be difficult for anyone but the model's developer to understand. The relationship between the computations in the code and the actual physical situation being modeled may be obtuse and indecipherable. Furthermore, a great deal of important information about various modeling assumptions is buried in the code and is difficult to recover. Finally, documentation may be minimal or lacking altogether.

Despite these well-recognized problems and despite the acknowledged importance of scientific model building, scientists today generally lack adequate software engineering tools to facilitate the development and sharing of modeling software.

The SIGMA modeling tool

A prototype knowledge-based software development environment has been constructed that makes it easier for scientists to construct, modify, share, and understand scientific models. The Scientists' Intelligent Graphical Modeling Assistant (SIGMA) system provides a type of "visual programming" environment customized for scientists.

The purpose of the SCIENCE INFORMATION SYSTEMS NEWSLETTER is to inform the space science and applications research community about information systems development and to promote coordination and collaboration by providing a forum for communication. This quarterly publication focuses on programs sponsored by the Information Systems Branch in support of NASA's Office of Space Science. Articles of interest for other programs and agencies are presented as well.

Rather than construct models using a conventional programming language, scientists use SIGMA's graphical interface to "program" visually using a high-level dataflow modeling language. The vocabulary of this modeling language includes high-level scientific constructs (e.g., physical quantities, scientific equations, and data sets) rather than low-level programming constructs (e.g., arrays, loops, counters). Because SIGMA enables users to express their models using a natural vocabulary and an intuitive format, colleagues can more rapidly understand and modify the content of a model without assistance from the modeler. These same characteristics make SIGMA an excellent instructional environment for demonstrating the principles underlying a scientific model.

During the model development process, SIGMA takes on the role of a knowledgeable and active assistant to the scientist rather than a passive and uninformed subordinate. SIGMA assists the scientist during the model-building process and checks the model for consistency and coherency as it is being constructed. Using knowledge about the modeling problem and the scientific domain, SIGMA can automatically interpret the high-level scientific model as an executable program, freeing the scientist from error-prone implementation details. Users can test these models, conduct sensitivity analyses, plot results, and modify models—all within the SIGMA environment.

The visual dataflow interface

Within SIGMA, the scientist views a computational model as a graphical structure called a dataflow diagram, as illustrated in Figure 1. This dataflow diagram represents the computational dependencies between the scientific quantities being modeled. By scanning the diagram, you can understand rapidly how one quantity is derived from others by applying a series of scientific equations.

The dataflow graph in Figure 1 consists of two types of nodes: equation nodes and quantity nodes. Equation nodes are depicted in thick-bordered boxes, while quantity nodes are depicted in thin-bordered boxes. The direction of computation in the dataflow graph is from right to left. The quantities at the extreme right represent known input data or exogenous quantities in the model. These quantities flow toward one or more equation nodes, where they are used in an equation formula to yield an output quantity. In turn, these intermediate quantities flow toward other equation nodes, and the entire computation cascades along as new quantities are computed and passed forward to new equations. The entire model execution culminates in the production of one

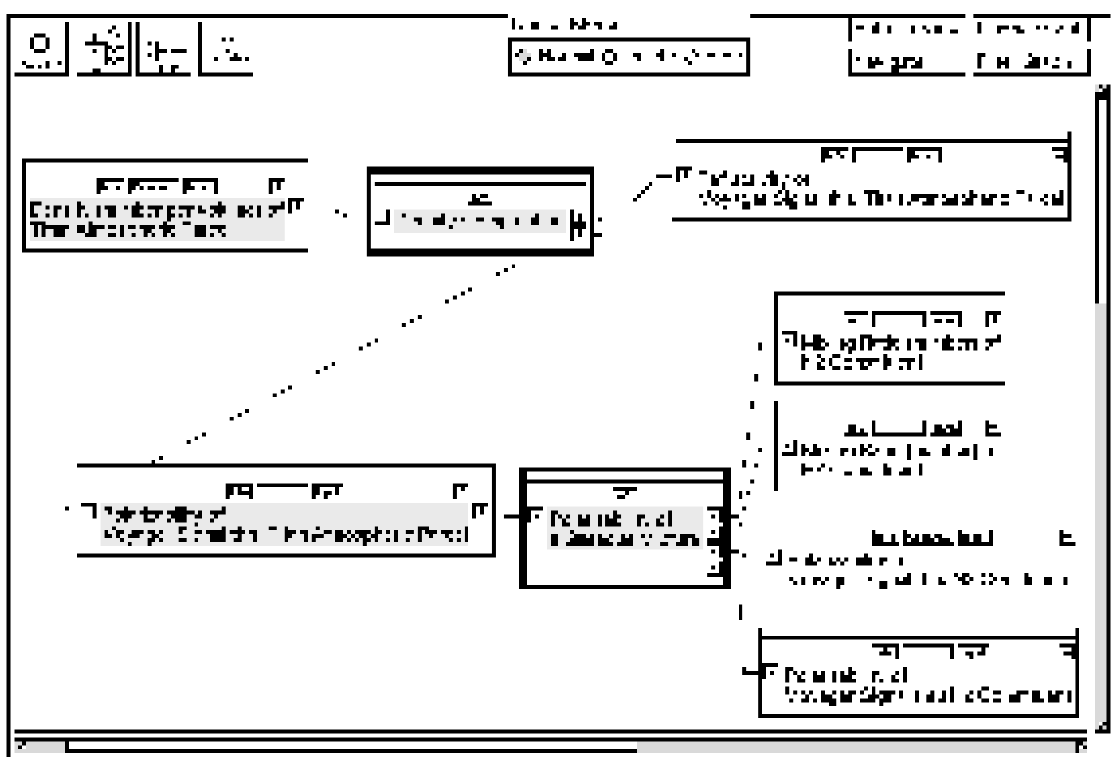

Figure 1. Data flow diagram representing computational dependencies in a model fragment

or more final output quantities at the extreme left of the diagram. To compute a model output, the user clicks on the *Compute* button for that output quantity node. Note that the *Compute* button is only active if all the required input quantities for the computation have been properly entered.

Accessing model information

You can access information about the model quantities and equations by navigating through the dataflow diagram. By clicking on the *Info* button for an equation node, detailed information about the equation is displayed, including the equation formula and its inputs and outputs. SIGMA can also display a literature citation providing documentation on the equation, including a scanned image of the original published source material. By clicking on the *Info* button for a quantity node, detailed information about the associated quantity can be accessed, including its numeric value, scientific units, documentation, and a literature citation. Clicking on the *Compute* button associated with a quantity node causes SIGMA to compute that quantity from the given inputs. The computed results can then be automatically converted into a desired set of units and plotted by the system.

Modifying the model

Aside from executing a model, you may wish to modify the model or to conduct a "what-if" type of analysis using SIGMA. The system facilitates modification because all changes are made via the high-level dataflow interface. No low-level programming changes need to be made. To change an input value, just click the *Input* button on an input quantity node and enter a new value. Any previously computed value that depends on this value is then invalidated; recomputation may be requested, if desired.

A more fundamental type of modification consists of changing one or more of the equations used to compute quantities in the model. This is done by clicking the *right arrow* button on the output quantity node of the equation to be modified. For example, to compute number density using a different equation than the Density Computation equation shown in Figure 1, click the *right arrow* button on the output number density node to get a menu of alternative equations to apply from among those in its library of over 150 equations. SIGMA maintains a record of the conditions under which each equation in its library is applicable. Using these conditions, the system selects viable alternatives for the current situation. SIGMA's library contains black box subroutines, as well as explicit scientific equations. Users may add their favorite FORTRAN or C subroutines to the library and these can be inserted into SIGMA data flow diagrams.

SIGMA's critical resource: science knowledge

There are a number of different visual programming tools available to scientists today, including tools for image processing and scientific visualization (Khoros, AVS, SGI Explorer, Iconicode/IDF), scientific instrument design (LabVIEW), and modeling or simulation (STELLA/IThink, Extend). Although these tools enforce simple syntactic checks on dataflow graphs and perform some type checking, none of these tools has an "understanding" of what the dataflow program is doing or whether the operations on the data make sense. Because these software tools have virtually no information about the application domain, they have no basis upon which to evaluate the appropriateness of a dataflow program for solving a particular application problem. As a result, it is possible with these tools to create a syntactically valid dataflow graph that is semantically incoherent and fails to solve the intended problem.

SIGMA is unique because it utilizes an extensive knowledge base of information about the scientific domain to assist the user during the modeling process. SIGMA's knowledge base contains both general-purpose science knowledge (e.g., descriptions of widely used quantities, scientific units, scientific constants, equations, scientific concepts) and problem-specific knowledge (information related to the specific modeling problem and scientific discipline). The general-purpose knowledge comes as a standard reusable component of SIGMA, while the model-specific knowledge must be added by the user to support each new modeling domain.

Utilizing its extensive knowledge base, SIGMA can provide the following types of unique knowledge-based support for the model builder:

- *Equation applicability testing*: SIGMA actively screens each equation in its library

Prepared for the Information Systems Branch (Code ST) through an agreement with the Jet Propulsion Laboratory (JPL). Questions on the newsletter effort may be sent to Sue LaVoie at: 818-354-5677; sue_lavoie@iplmail.jpl.nasa.gov. Changes of address, questions on content and suggestions for future inclusions should be routed to Sandi Beck at: 818-393-3768; sandi_beck@iplmail.jpl.nasa.gov

Editors for this issue are Sandy Dueck, Ames Research Center, and Sandi Beck, Jet Propulsion Laboratory

Readers are invited to contribute articles to the Science Information Systems Newsletter. Contributions should be sent electronically to the editor at: sandi_beck@iplmail.jpl.nasa.gov

Changes of address should be sent to: Sandi Beck, Telos Information Systems, M/S 168-514, Jet Propulsion Laboratory, 4800 Oak Grove Drive, Pasadena, CA 91109. For inquiries phone 818-393-3768.

Newsletter layout—Robin Dumas, JPL Graphics.

to determine whether it is applicable in the current modeling situation. You only see a viable set of candidate equations.

- *Model consistency checks*: During the model-building process, SIGMA works to maintain the global consistency and scientific coherence of the evolving model.
- *Equation entry error-checking:* When entering new scientific equations, SIGMA ensures dimensional consistency.
- *Automated scientific units maintenance*: During model execution, scientific conversion is done automatically to maintain consistency.
- *Reusable libraries: SIGMA's* knowledge base includes reusable libraries of scientific equations, quantities, and constants.

Establishing the modeling context

Aside from its extensive knowledge about the scientific domain, SIGMA has available a detailed description of the background context against which the modeling activity occurs. This background knowledge about the modeling problem is essential for proper understanding and communication with the scientist.

One of the first and most important steps taken by a scientific modeler is to create an abstraction of a given real-world modeling problem by casting it in terms of a set of equations. Thereafter, the problem can be solved purely using mathematics. Unfortunately, as a result of this initial abstraction step, an important link back to the original problem has vanished. Subsequently, model users may have difficulty making the connection between the equations and the real-world modeling context. Because the contextual information that gave rise to the set of equations is unavailable to these users, they may have a hard time understanding, interpreting, and modifying the model. Similarly, without the appropriate contextual information SIGMA cannot understand and assist users with their modeling tasks.

Within SIGMA, this essential connection to the modeling context is provided by linking the numeric computation depicted in the dataflow diagram with an object-oriented description of the physical system being modeled. This object-oriented description is referred to as the *modeling scenario.*

Figure 2 illustrates the modeling scenario upon which the dataflow diagram in Figure 1 is based. This diagram represents one portion of a model intended to compute an atmospheric profile of Saturn's moon Titan based on radio signals sent from the Voyager 1 spacecraft during its encounter with Titan in 1980. The scenario in Figure 2 describes all details of the Voyager/Titan encounter relevant

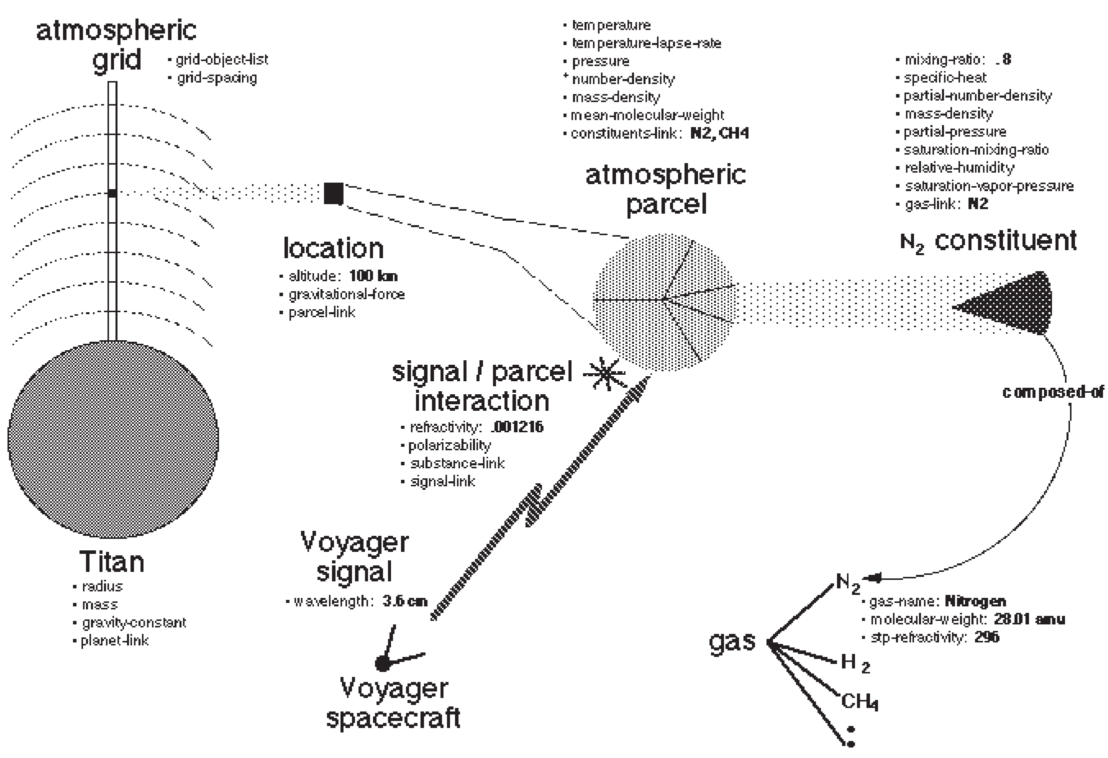

Figure 2. Modeling scenario for Titan/Voyager encounter

to the modeling task. Associated with the Titan object in the figure is an Atmospheric Grid of Location objects. At each location, there is an Atmospheric Parcel, which represents the mixture of gases at that location. Each parcel is composed of pure gas constituents, such as nitrogen. The Voyager signal originates from the Voyager spacecraft and subsequently passes through the parcel, where it causes an energy-matter interaction represented by the signal/parcel interaction object. Associated with each of these objects is a set of quantity attributes relevant to the modeling problem. Some of these attributes have known or assumed values, while other attributes are computed by applying scientific equations to the known attributes.

SIGMA relates the abstract numeric computation to the real-world modeling context by linking each quantity node in the dataflow diagram with a specific attribute of some object in the modeling scenario. For example, the node representing the density quantity in Figure 1 corresponds to an attribute of the atmospheric parcel object in Figure 2 called “number-density”, whereas the refractivity quantity corresponds to the “refractivity” attribute of the energy-matter interaction between the signal and the parcel.

SIGMA maintains useful information about each of the objects represented in the modeling scenario and their associated attributes. Each attribute has a text description and a set of associated scientific units. There is a hierarchy of object types, and each specific object instance in the scenario inherits information and attributes from more general objects in the hierarchy. For example, the Titan Atmospheric Parcel object is a specialization of the more general Physical Entity object. All subclasses of physical entity inherit attributes such as mass, density, and temperature, for example. By utilizing object-oriented techniques, SIGMA’s infrastructure is easily modified to accommodate new scientific domains. Two domains that have been worked on extensively are planetary atmospheric modeling and carbon and water transport modeling for forest ecosystems. Although these two domains seem quite different, they share in common some basic object and attribute definitions. SIGMA exploits these commonalities to reduce the burden of providing information to the system.

Status and limitations

SIGMA has been developed in close collaboration with scientists in planetary sciences and ecosystem sciences at Ames Research Center. SIGMA has been successfully used to reimplement and extend portions of two scientific models reported in the literature: *Titan Greenhouse Model* by C. P. McKay (Ames Research Center) and *Forest-Biogeochemical Cycles* by S. Running and J.C. Coughlan (Univ. of Montana).

SIGMA is a prototype system and is still undergoing development and testing. The current version of SIGMA is being tested by several different types of users:

- model developers who develop new models from scratch
- model users who primarily use models developed by others but who may need to make some modifications
- model observers interested in understanding a model, primarily for educational or training purposes

SIGMA has shown promise for all three categories of users, but currently its limitations are most serious with respect to the model developer.

SIGMA’s main limitation is the types of mathematical models that can be built within the framework. SIGMA currently handles noncoupled algebraic and first-order ordinary differential equations. However, many models require the use of simultaneous equations that cannot be handled easily within current system, although extensions are planned to facilitate their use.

SIGMA is written in CommonLISP and GINA, a Motif-based graphical user interface package. SIGMA runs on a Sun workstation.

For further information, contact the author via e-mail:

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or view the SIGMA Home Page at URL:

http://ic-www.arc.nasa.gov/ic/projects/sigma

Acknowledgments

The development of SIGMA has been an interdisciplinary effort, including contributions from many people over several years. Primary contributors include: Aseem Das, Jennifer Dungan, Caitlin Griffith, Chris McKay, Pandu Nayak, Esther Podolak, Michal Rimon, Michael Sims, and David Thompson. Thanks to Jennifer and to Barry Ganapol for providing useful comments on this article. Joint funding

SIGMA is unique because it utilizes an extensive knowledge base of information about the scientific domain to assist the user during the modeling process.

Calendar

MAY

08-12 Impact of Comet Shoemaker-Levy 9 on Jupiter (IAU Colloquim 156), Baltimore; MD; Michael A'Hearn; e-mail: ma@astro.umd.edu

09-10 Tenth Annual Goddard Conference on Space Applications of Artificial Intelligence and Emerging Information Technologies, Greenbelt, Md; James Rash, Phone:301-386-3595; URL: http://ddwilson.gsfc.nasa.gov

09-12 IAUC 156, "The Impact of Comet Shoemaker-Levy 9 on Jupiter"; Alex Storrs, Phone: 410-338-4903

12-13 Planetary Surface Instruments Workshop, Houston, TX; Publications and Programs Services Dept, Phone: 713-486-2166; e-mail: simmons@lpi.jsc.nasa.gov

JUNE

29-June 2 Eleventh Colloquium on UV and X-Ray Spectroscopy of Astrophysical and Laboratory Plasmas, Nagoya University Symposium, Nagoya, Japan; Tetsuya Watanabe, e-mail: watanabe@uvlab.mtk.nao.ac.jp

29-June 2 American Geophysical Union and Mineralogical Society of America Annual Spring Meeting, Baltimore, Md; AGU Meetings Dept; Phone: 202-462-6900

19-23 Gordon Research Conference on Origins of Solar Systems, New Hampton, NH; Anneila Sargent; e-mail: afs@mmstar.caltech.edu

AUGUST

14-18 IAU Colloquium 150:Physics, Chemistry & Dynamics of Interplanetary Dust, Gainesville, FL; M.S. Hanner; e-mail: msh@jplsc8.dnet.nasa.gov

27-Sept 1 IV International Conference on Advanced Materials—Planetary Impact Events: Materials Response to Dynamic High Pressure, Cancun, Mexico; Randall Cygan; Phone: 505-844-7216; e-mail: rtcygan@sandia.gov

SEPTEMBER

11-15 VLDB '95, Zuerich, Switzerland; Klaus R. Dittrich, e-mail: vldb95@ifi.unizh.ch

24-30 Mars Pathfinder Landing Site Workshop II: Characteristics of Ares Vallis Region, Spokane, WA; Publications and Program Services Dept, Phone: 713-4862166; e-mail: simmons@lpi.jsc.nasa.gov

OCTOBER

8-13 27th Annual Meeting of the Division for Planetary Sciences of the American Astronomical society, Kona, Hawaii; Karen Meech; e-mail: meech@pavo.ifa.hawaii.edu

26-27 Science Information Management and Data Compression Workshop, Goddard Space Flight Center, Greenbelt, MD; Jim Tilton, e-mail: tilton@chrpisis.gsfc.nasa.gov; Fax: (310) 286-1776

JANUARY 1996

22-26 New Extragalactic Perspectives in the New South Africa: Changing Perceptions of the Morphology, Dust Content, and Dust-Gas Ratios in Galaxies, Johannesburg, South Africa; David L. Block; Phone: 27-11-339-7965; fax: 27-11-716-3761

29 Feb 2 OSETI II: The Search for

Internet Availability

The *Science Information Systems Newsletter* is now available on the Internet at URL:

http://techinfo.jpl.nasa.gov/jpltrs/sisn/sisn.html

Please send comments or suggestions to Sandi Beck via e-mail:

sandi_beck@iplmail.jpl.nasa.gov

Multicast Backbone Between Washington and Moscow is Successfully Demonstrated

Tony Villasenor, Information Systems Branch, NASA Headquarters

On Monday, November 28, 1994, NASA Science Internet (NSI) supported a voice/video telecon between Washington, D.C., and Moscow over the public Internet. This originated as merely a proof-of-concept technical demonstration, not intended as a videocon for specific program discussions.

The Internet technology employed was "multicast," using Berkeley's network video (nv) and voice (vat) applications; no special equipment was needed. The United States side used a standard Sun Sparc workstation, and the Russian side used a standard DEC Alpha, courtesy of Digital Equipment Corporation. While the recommended bandwidth for full multicast is a minimum 384 Kbps, we operated point-to-point at just over 128 Kbps on our 256-Kbps satellite link to the Russian Space Research Institute, IKI (to minimize impact on operational e-mail, data transfers, and World Wide Web services between the United States and Russia). Getting used to "push-to-talk" operations was tricky at first but helpful in reducing feedback (unless headphones were worn).

Aside from demonstrating video/voice interoperability between opposite sides of the world, this telecon also demonstrated interoperability between workstations, languages, vendors, and operating systems.

The U. S. side was attended by:

- ST/, Chris Shenton, David Brown, and the author
- UO/Ed James, Chuck Doarn
- (other invitees from Codes S, Y, U, and O unable to attend)

The Russian side was attended by:

- Space Research Institute/Ravil Nazirov, Michael Zakharov
- Moscow State University/Oleg Medvedev, Vaseli Vasenin
- Kurchatov/Alexey A. Soldatov
- Russian Foundation/Alfimov M.V., Hohlov Yu.E.
- State Committee Higher Education/Tatur Yu.G.
- FREEnet/Andrej S. Mendkovich

Everyone felt that this demonstration was extraordinarily successful, since it used the public Internet with standard off-the-shelf equipment—no special video-conferencing setup at all. It was surprising that this demonstration was organized and set up just a few hours prior to the "live" conference to take advantage of a coincidental set of network-based meetings occurring that day in Moscow. As a result of the clarity and quality of this demonstration, all who participated are strongly interested in using this medium for future program collaborations. The live demonstration lasted about 45 minutes, long enough for all parties to exchange a few words and experience the modern world of Internet.

How quickly our world changes.

For more information contact the author via phone: 202-358-2224 or e-mail:
villasenor@nsipo.nasa.gov

Full Resolution Planetary Data System Image Data Available Over the Internet

Elizabeth Duxbury, Planetary Applications Group, Jet Propulsion Laboratory

Planetary

Data System

The goal of the Planetary Data System is to operate and maintain systems that enable the planetary science community easy access to numerous data sets and associated information from past and active missions. This is being accomplished through the joint efforts of seven Discipline Nodes staffed by working scientists, as well as the Central Node at Jet Propulsion Laboratory.

In the recent past, there has been a vast increase in the number of people accessing the Internet. This has been due in part to the recent development of the World Wide Web (WWW) and WWW browsers such as Mosaic and Netscape. The Planetary Data System (PDS) Imaging Node, in cooperation with other discipline nodes, has been seeking ways to use these resources to make NASA's planetary-image collection more easily available to the planetary science community and the public at large.

Several PDS nodes and other NASA organizations have recently acquired CD-ROM jukeboxes and now maintain significant collections of CD-ROMs online. While these resources are in themselves useful, and raw data can be accessed from them, it was recognized that the development of intuitive, user-friendly image browsers to access these data could further aid planetary researchers looking for a particular set of images. With this in mind, people at the PDS Imaging Node set about to develop an image browser for the 126 CD "Mission to Venus - Magellan: Mosaicked Image Data" dataset.

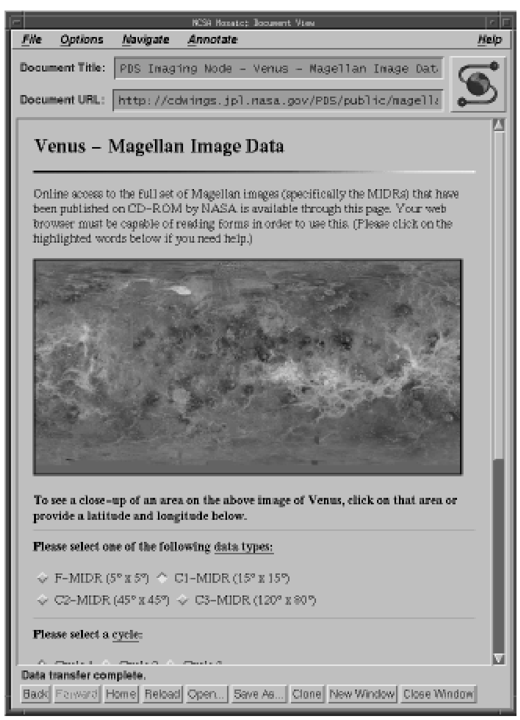

Figure 1. The Imaging Node's Magellan image browser displays a global picture of Venus, called an "imagemap".

Image browser capabilities

Currently researchers have to know in advance the location on CD-ROM of a particular image. However, now an image browser can determine image location for them. Providing this capability was accomplished by utilizing the capacity of most WWW browsers to accept user-provided criteria and input them to a program. The HyperText Markup Language documents (often referred to as HTML pages) that do this are called "forms."

The Imaging Node's Magellan image browser is one of these forms. It is designed so that, when it is first accessed, it presents you with a global picture of Venus, called an "imagemap" (see Figure 1). You indicate to the browser the location you are interested in by clicking with your mouse on this imagemap. The kind of product (full-resolution, compressed-once, compressed-twice, or compressed-thrice Mosaicked Image Data Record) and the mapping cycle (first, second, or third) can also be indicated on this form. This information is then fed to a PERL script which takes the information, calculates the coordinates on the planet that you've selected, and determines the product name for the desired image (ex. "c130n279"). The program then determines the location on CD-ROM of that product and displays a 256x256 pixel browse version of this image (see Figure 2). At this point you may choose either to download the entire image or sub-select one of the 56 image tiles that make up the browse image. This is done by again clicking on the image provided. You may then download full-resolution 1024x1024 images in VICAR format, if you wish. The Magellan images are stored on CD-ROM as VICAR images with detached PDS labels. The PDS labels may be downloaded separately through the image browser.

In order to make these data accessible to users, including the general public, who have relatively slow links to the Internet, or who do not have the capability of displaying VICAR images, the images may be converted to another format and scaled down before being downloaded. The formats currently available include VICAR and FITS (formats used in the planetary and astronomical communities respectively) and GIF, TIFF, JPEG, and PICT (formats displayable using software commonly available on UNIX machines, PCs, and Macintoshes). PDS formatted images should also be available in the near future. Since these conversions are all performed on computers at JPL, they are not limited by computer speed. This also obviates the need for obtaining your own image-conversion software.

The image browser also provides supplementary information about the chosen image, such as the product name or picture number (picno), its location on CD-ROM, and its size and format, etc. In the future, this list can be extended to possibly include such items as relevant feature names and the product names of corresponding images from other datasets.

Other image browsers

In addition to the Magellan image browser, a Viking Lander image browser has also been developed. Because the Viking Lander images were taken from the surface of Mars rather than from orbit, the method for accessing the data has to be significantly different. In this case, four imagemaps are provided, each of which is a mosaic of the images taken by the two cameras on each of the landers (see Figure 3). You select the lander and camera and then are presented with a higher resolution version of the mosaic. This then becomes the imagemap used to indicate a particular area of interest. Unlike the Magellan data, each selection may return a large number of images rather than a single image, so a list of the image picnos is provided from which the final image can be selected. In the future, the selection of these images will be further categorized by the time-of-day and time-of-year that the picture was taken.

Work is currently underway to develop an image browser for the Voyager images of both the gas giants and their satellites. In the future, similar browsers will be developed for the Viking Orbiter, Mariners 9 and 10, and eventually Galileo and Cassini missions.

Other resources

Because of the interlinking nature of WWW

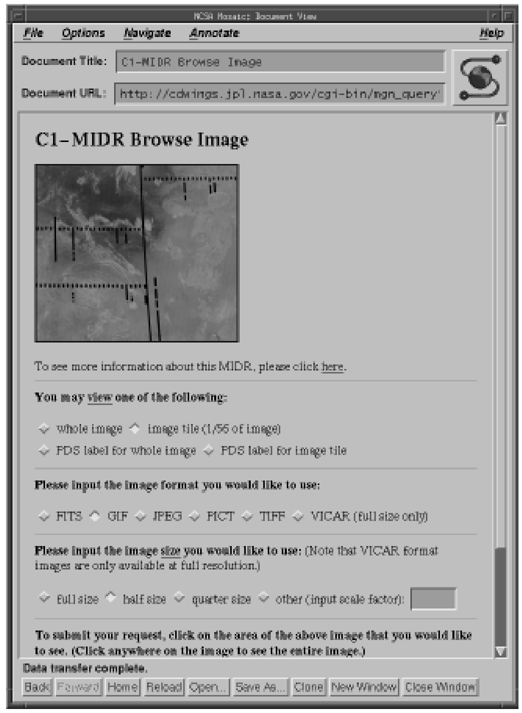

Figure 2. The Program display of a 256x256 pixel browse version of this image

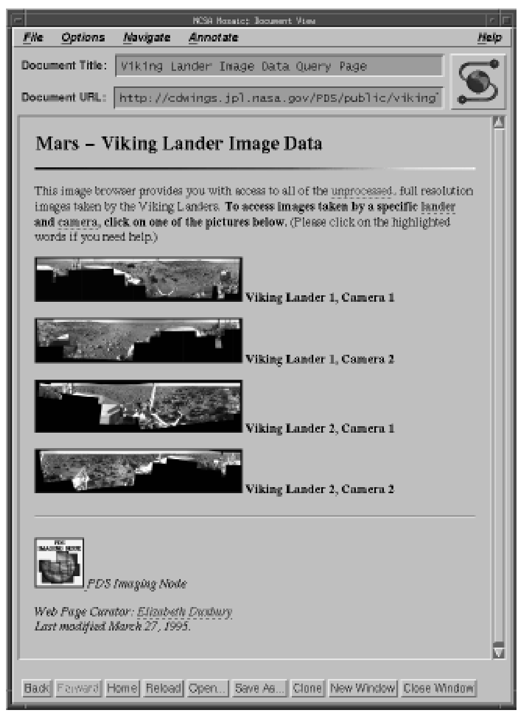

Figure 3. Display of the four imagemaps provided, each of which is a mosaic of the images taken by the two cameras on each of the landers

documents, it is a relatively simple matter to tie extensive supplementary resources into the Imaging Node's image browsers. For those unfamiliar with the dataset or the WWW, this can include help files that explain the different kinds of data products available and how to acquire them. Other links in the Magellan image browser provide access to the PDS Central Node's Dataset Catalog, their *Guide to Magellan Image Interpretation* and the online version of the JPL document *The Magellan Venus Explorer's Guide*. Similar resources will eventually be linked to the browsers for the other missions. For each of the major missions for which the Imaging Node archives data, there is also a list of other major sources of online data that are available at different sites on the WWW (see Figure 4).

Future capabilities

In the near future, the Imaging Node intends to provide a user-friendly, WWW-based interface to their product catalogs that will be extensively interlinked with the image browsers for each of the various planetary missions. This will provide researchers with such important information as: sun angle, spacecraft range, camera filters, and other data vital to image interpretation. Other potential additions include tie-ins to related datasets: the USGS-produced Magellan FMAPs, and the 3-D rendered images and movies of the surface of Venus produced by JPL's Digital Image Animation Laboratory.

To date, close to 3,500 people from forty-nine different countries have used the Imaging Node's web server to access information about NASA's planetary datasets via the Internet. Prior to the development of this high-level graphical user interface to the Imaging Node's planetary datasets, nonNASA-funded researchers had to pay for this data. Now these members of the planetary science community can obtain this data for free. Also, while there used to be a wait of several days for CDs to be shipped, the data can now be obtained immediately. JPL can support this level of access to a complete planetary image dataset using an automated system based on CD-ROM jukebox technology in an automated manner that requires an absolute minimum (approaching zero cost) level of operational resources. The data has simultaneously been made easily and freely accessible to the general public.

URLs for the Imaging Node and the Magellan and Viking Lander image browsers, respectively, are:

http://cdwings.jpl.nasa.gov/PDS/

http://cdwings.jpl.nasa.gov/PDS/public/magellan/midrcd_query.html

http://cdwings.jpl.nasa.gov/PDS/public/vikingl/vl_images.html

For further information contact the author via e-mail:

Elizabeth.D.Duxbury@jpl.nasa.gov

Image browsers and the other resources mentioned in this article can be accessed directly from the Imaging Node Home Page.

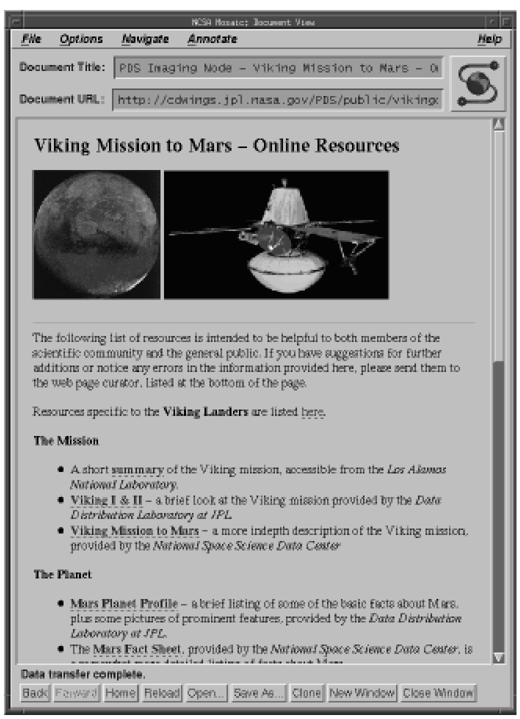

Figure 4. List of other major sources of online data that are available at different sites on the WWW

PDS Data Available on CD-ROM

Jean Mortellaro, Planetary Data System, Jet Propulsion Laboratory

The Planetary Data System (PDS) data listed below are all available on CD-ROM. These data can be ordered by accessing the *PDS Catalog* or by contacting the PDS Operator for assistance via one of the methods listed here. To use the P*DS Catalog* to place an online order, set host to JPLPDS or telnet to:

jplpds.jpl.nasa.gov

The user name is PDS_GUEST

The World Wide Web version of the *PDS Catalog* is available at URL:

http://stardust.jpl.nasa.gov

Under User Services select PDS Data Set Catalog.

For a complete list contact the PDS Operator via phone: 818-306-6130, or e-mail:

pds_operator@jplpds.jpl.nasa.gov

- Pre-Magellan Radar & Gravity Data - 1 Volume
- Magellan to Venus Full Resolution Mosaic Image Data - Volumes 1, 3-11, 13, 15, 17, 18, 23-29, 32, 35, 36, 38, 39, 42,44-46, 49, 50, 52, 53, 55, 56, 58, 59, 62-68 ,70-77, 80, 86, 87, 93, 94, 98, 101-111,119-123
- Magellan to Venus Compressed-Once Mosaic Image Data - Volumes 2, 12, 14, 16, 19-22, 30, 31, 33, 34, 37, 40, 41, 43, 47, 48, 51, 54, 57, 60, 61, 69, 78, 79, 84, 85, 88-92, 95-97, 99, 100, 112-117
- Magellan to Venus Compressed-Twice Mosaic Image Data - Volumes 30, 33, 34, 37, 43, 51, 54, 61, 69, 81-84, 90, 92, 96, 112, 118, 119
- Magellan to Venus Compressed-Thrice Mosaic Image Data - Volumes 69, 78, 84, 85, 119
- Magellan to Venus Altimetry and Radiometry Composite Data - Volumes 1-19
- Magellan to Venus Global Altimetry and Radiometry Data - Volumes 1-2
- Magellan to Venus Full-Resolution Radar Mosaics - 1 Volume
- Earth Geologic Remote Sensing Field Experiment - 9 Volumes
- International Halley Watch - Volumes 1-24
- Galileo to Jupiter Solid State Imaging REDR - Volumes 2-6
- Galileo to Jupiter Near Infrared Mapping Spectrometer EDR - 1 Volume
- Pioneer Venus Orbiter Magnetometer, Electric Field Detector, Ephemeris Data - Volumes 2-27
- Voyager to Jupiter - Volumes 19-24
- Viking Orbiter I to Mars Experimental Data Record images - Volumes 29-32(this completes the series)
- Viking Orbiter II to Mars Experimental Data Record images - Volumes 64 (this completes the series)
- Magellan to Venus Full-Resolution Radar Mosaics - Volumes 34-37,49-52,64-66,79-82,94-97,109-112,123-127,138,139
- Magellan to Venus Line Of Sight Acceleration Profile Data Record - 1 Volume
- Galileo to Jupiter Solid State Imaging Raw Experiment Data Record from Earth 2 Encounter - Volumes 7-15
- Pioneer Venus Orbiter Magnetometer, Electric Field Detector, Ephemeris Data Volumes 24-52
- Welcome to the Planets - 1 Volume

National Space Science Data Center OMNIWeb: A World Wide Web-Based Data Browsing and Retrieval System

Jason Mathews, Computer Engineer, and Syed Towheed, Systems Programmer, National Space Science Data Center, Goddard Space Flight Center

Users of science data are often in the difficult position of having to perform a suite of tasks to obtain data. These tasks can be broadly defined in three categories:

- finding the source for the data
- obtaining descriptions of the data
- obtaining the data

Once the source for the data is located, there is still the task of obtaining sufficient information about the data (metadata) to determine if it is adequate for your needs. Often, the metadata reside on some online information server (NASA Master Directory, NASA Master Catalog) that provides high-level descriptions of the data. However, rarely is the information server coupled with the data server. Even after you have found the data archive and obtained the metadata, there is still the additional task of determining which portion of the data is most likely to contain the phenomena or feature of interest. Even with textual browsing, you still cannot visualize the features of interest by just looking at a listing of numbers. Therefore, you are likely to request the entire data set.

Figure 1. OMNIWeb Home Page

OMNIWeb is a prototype data system that is the next logical development of World Wide Web (WWW) applications in the NASA environment, where the focus is to provide more sophisticated visualizations of data in addition to online data retrieval systems. OMNIWeb is designed to exploit the hypertext feature of the WWW and offer a single "one-stop-shop" interface to the metadata and the data, as well as an additional data browse capability to National Space Science Data Center's (NSSDC) near-Earth heliosphere data (OMNI). The goal is to empower the user by providing a cohesive, consistent, and transparent interface that eases the process of metadata and data discovery and thus gives the researcher more time to examine the actual data itself.

Methodology and interface design

All components of the OMNIWeb system adhere to the well-tested axioms of interface design, namely user control, transparency, flexibility, and learnability [COX93]. Also, the OMNIWeb components provide the most user-friendly interface possible under the current constraints of the Hypertext Mark-up Language (HTML) and WWW server and client software. In an effort to apply these axioms, a functional approach to systems design was taken by envisioning what tasks the user would be interested in performing and how those tasks ought to be performed. It is important to note that the entire project was approached from the users' perspective, not from the developers' point of view. To this end a "session" was modeled; a typical user interaction with the system starting from arrival at the Home Page, as shown in Figure 1, to the time the data are downloaded to his computer system. Defining a session helped to identify four functions that you may want to perform with OMNIWeb: browsing, retrieval; getting help, and supplying user feedback.

OMNIWeb, particulary the server-side software, was built to ensure that each component is as generic as possible. The interface to OMNIWeb is composed of the Home Page with links to the OMNIWeb Browser, the OMNIWeb retriever, a feedback form, and an extensive help file. The goal in the interface design was to utilize the visual feature of WWW to create an attractive and consistent interface. Banners and logos distinguish the pages and provide visual clues as to where you are and who provides the service. Graphic bullets highlight specific links and draw your attention. Control elements make the entire system easily navigable. A control panel was created from graphic buttons that appear near the top and bottom of most pages. The control panel lets you jump to other important areas in the system.

Current OMNIWeb features

The OMNIWeb Browser is a forms-based interface that allows you to input a start and stop date and select up to four parameters from the available data. The OMNIWeb Browser passes the selected parameters to a Common Gateway Interface (CGI) script called the OMNIWeb Plotter that, with graphical data analysis software, creates a GIF image that is transmitted back to your client.

The OMNIWeb Retriever allows you to obtain OMNI data. The process of data retrieval begins as you identify yourself by providing an e-mail address. You then select from two data delivery options; you may have the data displayed to the WWW client or copied to NSSDC's FTP site. You also have a choice of data formats for FTP retrieval. Selection of start and stop dates and required parameters within the OMNIWeb Retriever is almost identical to those operations in the OMNIWeb Browser. By default, the most common parameters are automatically selected. However, all of the available parameters may also be selected.

A forms-based feedback mechanism, to collect ideas and user opinion for improving OMNIWeb, is available from the OMNIWeb Browser, the OMNIWeb Retriever, and the Home Page. The inclusion of the feedback form is based on the philosophy that the best designer of any computer system is the user.

The OMNIWeb Help is designed to be a user's guide as well as a context-sensitive help file. When you select the *Help* button, or any of the hyperlinks from the data parameters, the link takes you to the most appropriate section of the help document. The location of the section is determined by which page you are on and which feature you are trying to exercise. For example, the *Help* button on the OMNIWeb Browser will jump to the Browser section of the help document.

Extensive error trapping was included to make OMNIWeb as user-friendly as possible. OMNIWeb was designed to treat an error not as a user problem, but either as a failure to present clear instructions or as a system problem. A typical error might result from invalid input values or missing fields. Other more serious errors might result from server problems, such as running out of disk space. Whenever an error is encountered, an error message, with a link to the appropriate help file, is displayed. This method provides you with both an explanation of the error and instant help.

OMNIWeb is constructed of CGI shell scripts and HTML generators, fill-out HTML forms, data-listing tools, data-subsetting and conversion tools, a graphical data analysis engine, an e-mail handler, and a cron clean-up script. The system diagram in Figure 2 shows all components of the entire system and how they interact.

All components of the system below the server layer are hidden from the user. You move from one page to another as a seamless transition since it is not apparent whether the document is a static page, such as the OMNIWeb Browser, or one of the dynamically created HTML pages, such as the output from the OMNIWeb Plotter. The system layer is composed of the low-level tools that access the data. The physical data files are represented on

All components of the OMNIWeb system adhere to the well-tested axioms of interface design, namely user control, transparency, flexibility, and learnability.

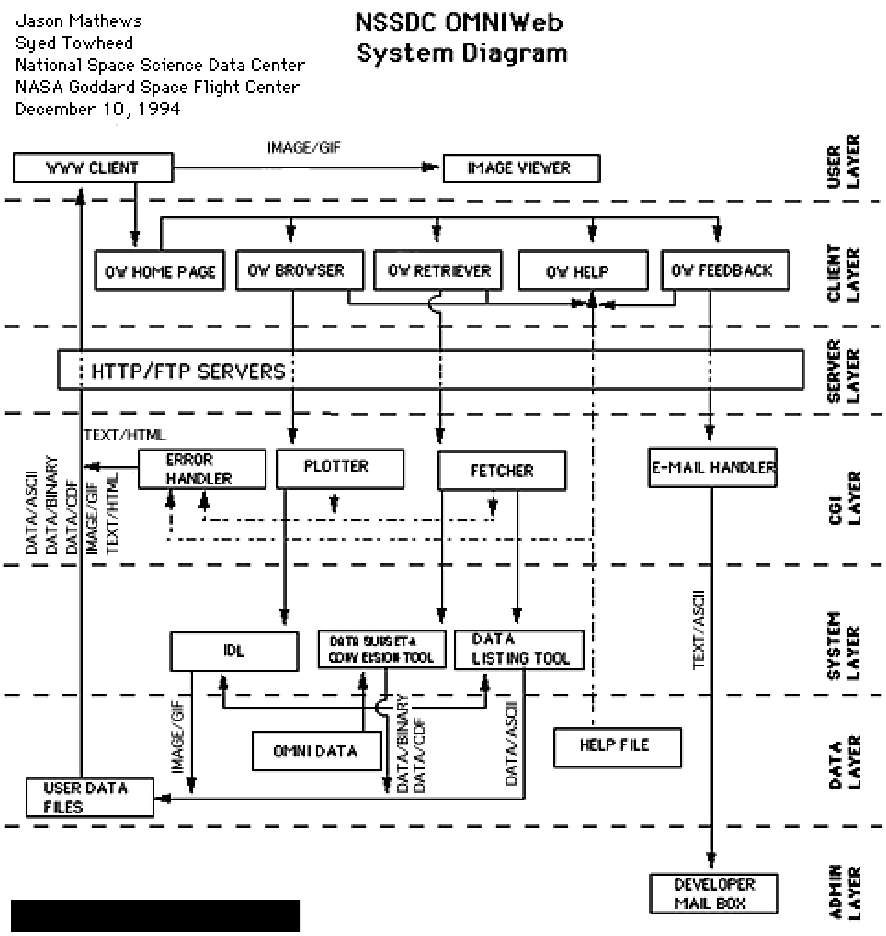

Figure 2. OMNIWeb System Diagram.

the data layer, from which the output is generated and displayed at the user's WWW client. The diagram shows the entire system from the user to the developer with the multiple layers that tie them together.

OMNIWeb provides the capability to query the data set for specific parameters, such as plasma temperature and ion density, over a time period from the OMNIWeb Browser, and the capability to view a time series plot of the selected parameters. The plot is created by the OMNIWeb Plotter with the graphics engine and is displayed as an HTML document.

Plots are generated automatically in the form of GIF files created by a graphical data analysis engine. The engine is a product from Research Systems, Inc. called the Interactive Data Language (IDL). IDL is primarily an interactive data analysis and visualization tool that offers an interpreted programming language and extensive library for plotting and analyzing data on many computing environments. However, IDL has the ability to compile modules fast, run in batch mode, perform all graphics output in memory, and write the results to a GIF file, which makes IDL ideal as a graphics engine for WWW-based data systems. Custom plots and images can be created by writing routines that call the appropriate IDL graphics, mathematical, and statistical library functions.

The user-selected parameters from the OMNIWeb Retriever are passed to the OMNIWeb Fetcher, a shell script that produces a subset of the data in either ASCII or binary format with the Data Listing Tool and Data Subset and Conversion Tool, respectively. Requesting the data as ASCII will generate a report that can be displayed directly to the WWW client as TEXT/HTML through the OMNIWeb Fetcher script or from an FTP connection. An example of an ASCII listing with the default 12 variables for a period of 24 hours is shown in Figure 4. The year variable has a FORMAT of “I2” that can be used to print an integer value with two digits. This attribute information allows generic tools such as the Data Listing Tool to work with different data sets and produce the desired results.

The Data Subset and Conversion Tool produces and converts the data from its native format to the user-selected binary format. The native format of the data is a machine-independent format known as the Common Data Format (CDF) [CDF94 and GOU94]. CDF is not just a data format but a data interface for applications that allows transparent access to self-describing data. The OMNI data are stored in CDF because CDF is unique in the sense that the data is portable across disparate platforms.

CDFs may be copied to any of the supported computers and read by any CDF application available for that computer, but the raw OMNI data are readable only on the specific machine because of different memory word representations.You need to keep track of which variables are a part of the raw binary file, what data types they are, what the record length is, and for what machine. OMNIWeb supports all of these data formats, and you decide how the data should be formatted.

The e-mail handler is based on the post_query.c code provided with the NCSA httpd 1.1 package released to the public domain. It composes the input given from the feedback form into an e-mail message, sends the message to the OMNIWeb developers, and responds with HTML output for an acknowledgment of acceptance or rejection.

A daily cron process will clean up all those files that can quickly accumulate by deleting all files older than two days and removing the empty directories. You have two days to retrieve data files located in a user-created directory.

Advanced features for OMNIWeb

In the near future there are plans for improving OMNIWeb. OMNIWeb Browser currently offers a selection of variables and the time range (start/stop dates) to create a plot. This interface will be extended with an “options” feature that saves the selections on the OMNIWeb Browser as hidden fields on a new dynamically created form, with advanced graphics options, to customize the output to a much greater degree. Submitting this new form will generate the plot however requested. The initial browsing interface uses default graphics options that should satisfy most users’ requests. Also, this new form will provide more control. Some advanced features might include other plot types such as histograms, plot and background colors, image size, plot symbols, logarithmic scaling of the axes, and the ability to spawn an external image viewer rather than generate an HTML document with in-line GIF images.

OMNIWeb, and systems like it, have the potential of radically shifting the paradigm with which researchers currently acquire data. Not only does it offer instant access to data, but has the added feature of supporting interactive data analysis. The WWW has allowed the folding of network-based data retrieval and analysis seamlessly into the core of research activity.

Related URLs:

[OMNIWeb System] http://nssdc.gsfc.nasa.gov/omniweb/ow.html

[NSSDC Home Page] http://nssdc.gsfc.nasa.gov/nssdc/nssdc_home.html

[CDF Home Page] http://nssdc.gsfc.nasa.gov/cdf/cdf_home.html

[IDL Home Page] http://sslab.colorado.edu:2222/projects/IDL/idl_ssl_home.html

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Listing for OMNI data from 73001 to 73001

YR	DAY	HR	$\lvert B \rvert$	F	THETA B	PHI B	T	N V	V V	PHI	THETA
73	1	0	0.0	0.0	0.0	0.0	111415	8.5	511	0.0	0.0
73	1	1	4.3	2.8	-6.0	11.0	111415	8.5	511	0.0	0.0
73	1	2	4.8	4.3	-14.0	283.0	111415	8.5	511	0.0	0.0
73	1	3	5.7	4.2	-14.0	295.0	129077	9.4	510	0.0	0.0
73	1	4	6.2	4.2	-42.0	288.0	129077	9.4	510	0.0	0.0
73	1	5	5.5	3.7	53.0	330.0	129077	9.4	510	0.0	0.0
73	1	6	5.5	4.7	38.0	332.0	129898	5.9	534	0.0	0.0
73	1	7	4.6	3.5	3.0	313.0	129898	5.9	534	0.0	0.0
73	1	8	4.0	2.7	19.0	346.0	129898	5.9	534	0.0	0.0
73	1	9	4.0	3.2	-10.0	4.0	106285	5.5	523	0.0	0.0
73	1	10	4.0	3.0	6.0	342.0	106285	5.5	523	0.0	0.0
73	1	11	4.2	3.0	-12.0	339.0	106285	5.5	523	0.0	0.0
73	1	12	0.0	0.0	0.0	0.0	89247	5.2	520	0.0	0.0
73	1	13	0.0	0.0	0.0	0.0	89247	5.2	520	0.0	0.0
73	1	14	4.2	4.0	53.0	33.0	89247	5.2	520	0.0	0.0
73	1	15	4.0	2.1	38.0	331.0	85643	4.4	515	0.0	0.0

Figure 4. Sample ASCII Data Listing from OMNIWeb

The authors are indebted to Joe King, NSSDC, for providing the OMNI data set and to Nathan James for providing unlimited access to the NSSDC Online Data and Information System. The IMP 8 magnetic field and plasma data were provided by Ron Lepping, GSFC, and Al Lazarus, MIT.

The Imaging Radar Home Page; A Valuable Resource

Bruce Chapman and Tony Freeman, Radar Science and Engineering, Jet Propulsion Laboratory

Jet Propulsion Laboratory (JPL) has led the development of imaging radar sensors and techniques for scientific applications for almost 20 years. The users of the radar image data generated by this program have been the 'traditional' users associated with most NASA research programs, i.e. scientists selected by peer review who use the data in their investigations in the fields of geology, hydrology, ecology, oceanography, and remote-sensing techniques.

Recent successful flights on the space shuttle Endeavour of a sophisticated imaging radar known as SIR-C/X-SAR and the success of radar imaging sensors ERS-1 and JERS-1 (placed into orbit by the European Space Agency (ESA) and the Japanese Space Agency (NASDA) respectively) have led to an increased level of interest in radar image data from outside the traditional NASA user community. This nontraditional user community includes researchers not usually associated with NASA, such as: archaeologists and conservationists; educators looking for new ways to teach physics, maths, and geography; and commercial companies searching for image data over sites that have potential oil, gas, or mineral deposits.

Radar image data on the Web

As part of an outreach program set up to deal with the increased level of interest, JPL has set up a site on the World Wide Web (WWW) known as the NASA/JPL Imaging Radar Home Page. The questions most frequently asked by new users of radar image data are as follows:

- How can I get data?
- How can I get data over to my site?
- How can I get data over to my site when I want it?
- How do I handle the data when I get it?

These are difficult questions to answer. Each user has different requirements for coverage and different levels of expertise in handling radar image data. The NASA/JPL Imaging Radar Home Page was set up to try to answer some of these questions. The site contains:

- a bulletin board to facilitate communication within the growing imaging radar community
- samples of radar image data from NASA's imaging radar sensors
- links to other sites with radar image data archives, such as the EROS Data Center, the Alaska SAR Facility, and facilities operated by the ESA and the NASDA
- links to online educational materials at the AskEric Web server
- instructions on how to obtain basic data-handling software
- information about the SIR-C data outreach program
- the latest news and images from JPL

The URL of the NASA/JPL Imaging Radar Home Page is:

http://southport.jpl.nasa.gov/

20 years of radar imaging

JPL's imaging radar program began almost 20 years ago with a series of experimental radars flown on rockets and aircraft. This program has led to a number of notable technical achievements, including development of:

- the world's first Spaceborne Imaging Radar (Seasat, 1978)
- the discovery of buried river channels in the Sahara desert using imaging radar (SIR-A, 1981)
- the first multi-angle, digital imaging radar system in space (SIR-B, 1984)
- the Magellan imaging radar that mapped over 95% of the surface of Venus (1990-

1994)

- the first multipolarization, multifrequency imaging radar flown in space (SIR-C/X-SAR, 1994)

In addition, a parallel airborne radar development program has resulted in the enormously successful AIRSAR imaging radar/interferometry system that has flown missions to collect radar image data for scientists all over the world since 1988. Other significant technological developments include:

- the first digitally processed SAR images (1979)
- the first real-time spaceborne SAR data processor (1982)
- the first demonstration of the interferometry technique using repeat orbits (1984)
- the first demonstration of a technique known as differential interferometry for detecting small surface elevation changes (1986)
- the first geocoded or georeferenced SAR image data (1984)
- the first polarimetric imaging radar system (1984)
- the first fully calibrated imaging radar system (1989)

The key to the success of the JPL imaging radar program has been the development of multichannel imaging radars such as SIR-C and AIRSAR that operate simultaneously at several radar wave lengths and several polarizations. The result is as dramatic as the difference between black and white and color film. With multichannel radar, interpretation of the images is much easier.

This wealth of radar imaging information being accumulated is of interest for a large variety of scientific and commercial applications. Outside the developed countries of the world, many areas remain poorly charted. Radar can peer through perpetually cloudy areas to see rivers, mountain features, lavaflows, deforestation, glacier movements, and snow pack moisture content. In dry desert areas radar penetrates beneath the surface to see ancient riverbeds. Over the oceans, currents and weather fronts are visible. With radar images of agricultural fields, different crops and their state of growth may be distinguished and water drainage patterns identified.

The Home Page as a resource

The Imaging Radar Home Page is geared to three audiences: scientific and commercial investigators of imaging radar data, educators looking for innovative teaching tools, and the general Internet community. Scientific and commercial investigators may access the home page to find out about availability of data at specific areas: for instructions on obtaining software for analyzing radar data; for online access to low resolution data products (advantages: no waiting for data to be sent through the mail, reduced likelihood of getting the wrong data, users may "browse" through data products); and for communication to users of radar data through a bulletin board.

Educators may find a link to online CD-ROMs with high-school-level teaching guides, software tools, interactive activities, and suggested problems for students to solve. Instructions are also given on obtaining CD-ROMs through the mail, along with example student activities, and forthcoming materials. The general Internet community may find: radar images of their home town; 3-D animations of flights through Death Valley, the Galapagos Islands, and an erupting volcano in Kamchatka, Russia; 3-D perspective views of Pasadena, Calif., and Mt. Pinatubo, Philippines; Anaglyphs of Mt. Everest (requires 3-D glasses for viewing); and contour maps of Mammoth Mountain, Calif. Clearly, each of the three target audiences will have overlapping interests in all the materials.

The most immediate needs are to direct users of the home page to the sources they desire to obtain, to set up sample data sites, and to indicate to users the potential usefulness of this information server. The long-term objective is to provide a location where radar remote-sensing data can be obtained easily over the Internet, along with educational resources to broaden the community that may use the data. A typical user would access the home page, click on a map of the world, and find online radar data; from that site, from a variety of instruments, and in a variety of data presentations.

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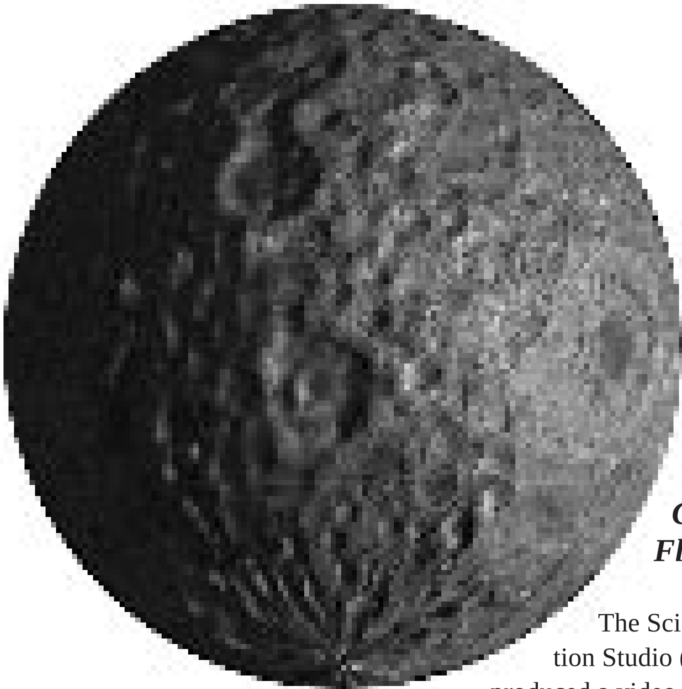
This wealth of radar imaging information being accumulated is of interest for a large variety of scientific and commercial applications.



The lunar farside, centered on the giant impact basin South Pole-Aitken. The area is nearly 2500 km in diameter and has 12 km of topographic relief. Smaller multiring basins, Apollo (center), Orientale (right edge), and Korolev (upper left-center) are visible.

Scientific Visualization Studio Produces Video of the Moon's Topography

Judy Laue, Hughes STX Corp., Space Data and Computing Division, Goddard Space Flight Center

The Scientific Visualization Studio (SVS) has produced a video animation depicting recent discoveries of the moon's topographical features. Created from Clementine mission data, the video is a product of advanced production techniques and equipment at Goddard Space Flight Center's (GSFC) Space Data and Computing Division (SDCD) combined with data analysis by Principal Investigators David Smith and Maria Zuber (Johns Hopkins University) and Co-Investigators Frank Lemoine (University of Maryland) and Gregory Neumann, Department of Earth and Planetary Sciences, Johns Hopkins University.

Clementine data

The Clementine Mission was a joint Department of Defense/NASA project that was originally part of *Star Wars*, the Strategic Defense Initiative. The spacecraft carried a laser-ranging instrument (LIDAR) as well as cameras and other sensors that could be used to measure the moon's topography. The LIDAR collected one half-hour of data per five-hour orbit over the course of the two-month lunar-mapping mission.

Investigators applied special techniques to analyze the Clementine data to create a digital topographic model. These techniques helped to reveal previously unknown details of the moon's important impact features, including Orientale and South Pole-Aitken, and led to the discovery of several ancient, degraded craters created by early lunar impacts.

Video production

The SVS produced the video for the Laboratory for Terrestrial Physics. Cindy Starr generated the video on the SVS dual-processor Silicon Graphics (SGI) Onyx workstation using 512 MB of memory and up to 6 GB of disk storage. She imported images into the AVID Media Suite Pro running on an SGI Indy for editing and then recorded the images to Betacam in real time.

To visualize the topographic dataset received from the Clementine science team, Starr converted the data into formats that could be read into the SVS visualization software system, including the Application Visualization System, the Flow Analysis Software Toolkit, and Wavefront's Advanced Visualizer (TAV), which is the SVS's high-end animation system. She produced a texture map consisting of 16 MB of data from a high resolution lunar image. Within TAV, she experimented with material properties and lighting to create the most realistic view of the data. She also generated a flight path that zoomed in from a distant viewpoint and circled the southern hemisphere at about 20 degrees south. The topography was exaggerated by a factor of seven to provide an optimum view of the lunar features. It took nearly three of weeks of wall-clock time on the SGI Onyx to generate the 1.5-minute animation.

The video was presented at the Clementine Calibration Meeting on January 23, 1995, in Flagstaff, Arizona. Mike Belton, Galileo Solid-State Imaging system team leader, approved a second SVS video production based on Clementine-Galileo composite lunar visualizations of topography and color to show the dramatic correlations between the moon's topography and composition.

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NASA Science Internet Coordinates Communications for Kilauea Volcano Project

Marsokhod required T1 connectivity (1.544 Mbps data rate) between the Hawaii Volcano Observatory and ARC. The lunar portion of the mission incorporated real-time video and IP data from the rover back to ARC for command and control of the vehicle. During the Mars and educational outreach portions of the mission, freeze-frame video and IP data were transmitted to ARC over the data portion of the circuit. Data and real-time video were multiplexed (sent simultaneously on a single radio frequency) using CLI Rembrandt II/vp codecs (coder/decoder). The Mars and lunar tests used an Electronic Data System (EDS)-supplied satellite.

The ARC ground station received the data and video signals from the Federal Internet Exchange (FIX-West) gateway via a Williams Telecommunications Company's (WilTel) T1 circuit from the EDS ground station in Plano, Texas. Video was sent from the gateway to the codec, to VidNet, and then to NASA Select. The data portion was routed through the ground station and onto ARCLAN and the Internet.

Communication and control of Marsokhod were accomplished wirelessly, as contrasted with the earlier Dante II robot in Alaska that was controlled via a tether. Data from the Marsokhod rover were transmitted to and from the vehicle (at .9 GHz) using two ARCLAN wireless ethernet bridges; one mounted on the rover and one located at Hawaii Volcano Observatory (HVO) on the volcano's rim. The bridge at HVO was connected to an NSI router that was connected to the CLI codec. The codec multiplexed the data and video to and from the rover. Video from the rover was transmitted to and from the vehicle (at 1.2 GHz) using two wireless PowerPlate video transmitters; one mounted on the rover and a second unit located at HVO that was connected to the CLI codec. Voice communications on Hawaii and between Hawaii and ARC were conducted over cellular phones donated by U.S. Cellular and satellite connectivity was supported by EDS and WilTel.

Following NSI's involvement in the lunar and Mars simulations, the rover was moved from the volcano to a point on the shoreline for several educational and public outreach programs. During this phase in early March, the EDS JASON Island Earth project sponsored a nationwide educational outreach project that allowed students at ARC and 20 other Primary Interactive Network sites to participate in live interactive television broadcasts from Hawaii and to operate the rover.

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The Marsokhod communications support was coordinated by NSI Lead Engineer Keith Brumbaugh and NSI Requirements Manager JoAnn Nelson with the aid and cooperation of several groups within NASA as well as personnel at EDS and WilTel.

The Russian-built Marsokhod teleoperated rover was tested at the Kilauea volcano in preparation for a planned 1998 lunar exploration mission.

NSI

NASA Science Internet

The NASA Science Internet program develops and operates computer networks for NASA's space science and applications community to enable researchers worldwide to connect to science databases, computational resources, and to each other for collaboration.

South Pole Live Telecast a Historic First

Roxanne Streeter-Evans, NASA Science Internet, Ames Research Center

On January 10, 1995, (January 11 in Antarctica) the NASA Science Internet (NSI), in cooperation with the National Science Foundation (NSF), accomplished the first-ever live video telecast from the South Pole. The "Live From Antarctica" telecast was one in a series of four live interactive Public Broadcasting System shows produced by Geoffrey Haines-Stiles that are popularly known in the NASA Kindergarten through 12th grade (K-12) community as "virtual field trips."

NSI engineers Thom Stone and the author teamed with engineers from the NSF and the Antarctic Support Associates (ASA) to design and implement a combination of complex video and audio links to facilitate live interviews with researchers at the Amundsen-Scott South Pole Station, connecting them interactively to K-12 classrooms across the U.S. Months of preplanning were required to ensure that all engineering, procurement and logistical issues were addressed. NSI engineers were then deployed to Antarctica to become part of the on-location field crew, bringing to the table previous years of Antarctic engineering experience.

The telecast link

The telecast link at South Pole was made possible by a combination of fiber optic, microwave and satellite technologies. The film crew on location sent live video and audio signals via microwave to a microwave receiver on a nearby science building where the signal was interfaced to interbuilding fiber optic cables. There the signal was relayed via fiber to the communications center inside of the South Pole station dome, sent through switching and compression equipment, and uplinked to the GOES-2 satellite that is visible above the South Pole horizon for approximately six hours a day.

The signal was then downlinked and uncompressed in Malabar, Florida, where it was satellite up-and-downlinked for a second time to reach the broadcasting studio at

The Amundsen-Scott South Pole Station geodesic dome is the center of activity at the Pole housing the winter living quarters, galley, and library. (Photo by Roxanne Streeter-Evans.)

NSI engineers Roxanne Streeter-Evans (front) and Thom Stone (far right), with Geoffrey Haines-Stiles Productions personnel Brian Igelman (far left), Deane Rink (second from left), and Chuck Kramer (fourth from left). New Zealand mountaineer John Roberts (center) was responsible for personnel safety.

Maryland Public Television. Here production experts edited and mixed the live signals from South Pole with the signals from live classrooms in Chicago, Virginia, and Hawaii, adding some pre-edited footage. The final product was then relayed via a third and final satellite link to PBS stations across the U.S. An additional audio link was provided by NSI utilizing a small, transportable earth station and the MARISAT F3 satellite.

The average temperature during telecasts was approximately minus 20 degrees Fahrenheit making working outdoors, as was required for the live movement of the geographical South Pole marker, extremely difficult. Cameras were outfitted with “polar bear” covers (padded jackets) with chemical heat packs inside to keep moving parts from freezing. Technical crew and “talent” alike had to work while wearing full Emergency Cold-Weather gear.

The NASA K-12 project staff also worked to provide the K-12 community with an interactive information server containing the Antarctic journals of researchers and explorers “on the ice,” question-and-answer bulletin boards, and informational resources about the frozen continent utilizing advanced technology to creatively shape the learning process.

NSI achievements

NSI’s achievement marks the second such accomplishment. The first-ever live broadcast from the Antarctic continent, made possible by NSI in cooperation with NSF and ABC-TV, was from McMurdo Station, Antarctica, during the 1992-93 austral summer season. NSI now adds another first, participation in the first-ever live broadcast from the South Pole, the farthest possible southerly location on the Antarctic continent and on Earth.

NSI continues to support NASA science and researchers in Antarctica by providing Internet access from remote locations on the Antarctic continent to colleagues and data resources across the U.S. and internationally.

For more information contact the author via e-mail:

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The telecasts were produced by Geoffrey Haines-Stiles Productions and Maryland Public Television, with sponsorship, in part, by NASA, the National Science Foundation, the Department of Energy, and the PBS K-12 Learning Services.

NASA Science Internet Office Provides Support to NASA-Funded Education and Networking Projects

Lenore Jackson, NASA Science Internet, Ames Research Center

The NASA Science Internet (NSI) planning office provides network support to the Minority University Space Physics Interdisciplinary Network (MUSPIN) and the NASA/University Joint Venture (JoVe) projects. Networking capabilities are a significant factor in both program participant's endeavors. Scientists at NASA centers are able to mentor colleagues at universities by utilizing the network. University participants are then able to formulate curriculum by utilizing online resources.

MUSPIN

The MUSPIN project was funded and launched in 1991 at Goddard Space Flight Center in response to requests for networking programs for historically black colleges and minority universities. The objective is to promote awareness and usage of wide area networking technology in support of collaborative interdisciplinary scientific research among faculty and students in conjunction with NASA scientists.

To date, the NSI within MUSPIN has demonstrated the efficient utilization of networking by:

- hosting workshops for Internet training and usage
- providing dial-up capabilities to those sites that have no infrastructure in place to support network connectivity
- attending annual user conferences to disseminate project information and resources
- providing technical assistance by distributing network starter kits to user sites

In FY 95/96 MUSPIN plans to establish regional training centers across the U.S. in order to reach a broader audience within the user community, as well as to share resources and talents. The NSI will assist the MUSPIN project by facilitating the establishment of regional training centers utilizing networking capabilities to distribute information.

JoVe

The JoVe project was created in 1989 to establish a partnership between NASA and other institutions of higher education in order to formulate a working relationship with NASA's space program. The JoVe program is located in Huntsville, Alabama, near the Marshall Space Flight Center. Within the JoVe program, students and faculty work with mentors at NASA centers utilizing their network connectivity to collaborate on ongoing projects once the grant recipients return to their home sites.

Contributions by the NSI within the JoVe program include:

- providing assistance in instances where local area network issues were constraining acquisition of networking services
- assisting the project with obtaining additional funding from other sources in order to ensure continued connectivity after the NASA three-year grant cycles expire
- providing information and referrals when needed in support of hosting wide area connectivity

As a part of the NSI's collaboration with these projects, yearly support is offered at both users' working groups annual meetings, as well as ongoing technical collaborations throughout the year. The NSI will assist with networking support for the sixth annual JoVe retreat/conference in July 1995.

If you wish to know more about these projects, as well as contact information, contact the author via phone: 415-604-0455 or e-mail:

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Educational Access to the Internet

Using The Science Information Infrastrucure And the Science OnLine Program

Karen Alcorn, Center for EUV Astrophysics, University of California at Berkeley

Imagine you are a ninth grade science teacher interested in utilizing information available on the Internet to teach your class. You have heard that there are exciting visual images, interactive activities, and games that could give your students motivation for understanding a NASA satellite's operations, astronomy, and space science.

Presently, locating this information is a difficult task. Much of the data, images, and text available on the Internet have been created for audiences other than the Kindergarten through 12th grade (K-12) community, and are distributed widely across different World Wide Web (WWW) sites or are not yet online. However, an increasing number of professional educators are working to adapt Internet information for use in the classroom. At the Center for EUV Astrophysics (CEA), Carol Christian has created a Science Information Infrastructure (SII) with funding from the NASA High Performance Computing Center 1994 Cooperative Agreement Notice program, with partial support from NASA's Astrophysics Division. Designed to deliver the latest discoveries in Earth and space science research to the general public, SII is a collaboration of NASA researchers, educators, industry, and science museums.

The role of science museums

Because NASA researchers retain a primary focus on conducting high-quality scientific research and on educating their students within colleges and universities, the nation's science museums are a crucial link between the public and research institutions. Science museums are experts at translating science and technology into a digestible form for the general public. In addition, science museums continue to fill this role long after individual NASA missions end. SII's science museum collaborators are: the National Air and Space Museum in Washington, DC, the Exploratorium in San Francisco, the Science Museum of Virginia in Richmond, the Lawrence Hall of Science in Berkeley, the New York Hall of Science in New York City, and the Boston Museum of Science. The research institutions are: the CEA in Berkeley, the Smithsonian Astrophysical Observatory in Cambridge, and the Center for Earth and Planetary Science in Washington, DC.

Through SII, the science museums are receiving Internet access and computer hardware and software, as well as technical training, scientific expertise, and, in the long term, consultation on location and interpretation of science data provided by the research institutions. The museums will maintain online science resource centers for all who visit the museum, including "virtual" visitors; those with Internet access.

This information infrastructure allows other researchers and science museums to integrate with, share, and augment the network, resulting in a coordinated, ever-expanding flow of information from research institutions through museums to the public.

A collaboration: science and educators

A pilot program for SII, called the Science OnLine (SOL) program, is being directed by Isabel Hawkins of the CEA. This program is a collaboration between NASA scientists at the CEA, science museums, and K-12 educators. The SOL project aim is to use online science exhibits, data from space and Earth missions, and NASA images to develop lesson plans.

Sixteen teachers participated in the SOL teacher orientation workshop at the CEA this past November. The workshop introduced teachers to the WWW through the Mosaic interface and assisted them in finding and using hypertext links to text pages, images, and video and audio clips.The workshop also included hands-on activities such as:

- EUVE Satellite Data Flow
- Phases of the Moon
- Size and Distance of the Earth, Moon, Sun, and Stars
- Developing the Geologic Time Scale
- The Hands-on Universe

Teachers commented that these demonstrations had strong potential to spark interest in science among their students.

Workshop participants are now developing their own SOL WWW lesson plans and hands-on activities. They are collaborating with the Adler Planetarium in Chicago and the Center for EUV Astrophysics, the Lawrence Hall of Science, and the UC Museum of Paleontology in Berkeley. The resulting lesson plans will later be pilot-tested by teachers at the Exploratorium in San Francisco as a test case to demonstrate the effectiveness of SII. Soon educators across the country will benefit from these lesson plans. SOL teachers will be able to show their students how to access weather data from Mars and Earth, as well as data from the Extreme Ultraviolet Explorer (CEA's satellite). These lesson plans will be an easily accessed resource for all teachers interested in challenging and inspiring their students with the latest discoveries in science.

Together, the SOL and the overearching SII programs seek to contribute long-lasting and significant improvements to the scientific and technological literacy of this nation.

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Other contributing authors: Isabel Hawkins, Carol Christian, and Roger Malina of CEA/UCB and Robyn Battle of the UCB School of Education.

Astrophysics Data System

The goal of the Astrophysics Data System is to provide the astronomy researcher with easy access to a wide variety of astronomical data. The objective of ADS is to explore the unique value of each supplier of data and services and to provide access to that value by the science community at large.

New Services and Data in the Astrophysics Data System

The main emphasis of the Astrophysics Data System (ADS) Astrophysics Science And Information System (ASIAS) is to provide access to bibliographic services. The abstract server software has been rebuilt to enable the inclusion of abstracts from other sources on a regular basis. This greatly increased the number of references in the ASIAS. Also, ASIAS has begun providing access to full journal articles, both online and stored images.

Abstract database

With the new software capabilities, there are plans to include many more original author abstracts from astronomical journals. Currently, abstracts from *Astronomy and Astrophysics*, the *Observatory Reports* from Skalnate Pleso, Slovakia, and the *Proceedings of the Astronomical Society of the Pacific* are being included. Similar arrangements are being discussed with the *Astrophysical Journal* (ApJ), the *Astrophysical Journal Letters* (ApJL), and other journals. This new capability will allow searchable abstracts to be much more up-to-date.

References from the Set of Identifications, Measurements, and Bibliography for Astronomical Data at the Centre des Donnees astronomiques de Strasbourg have already been included in the ASIAS. These references have no abstracts, but they are searchable by words in the title and by authors. Also included are the complete references (no abstracts) for the ApJ, ApJ Supplements, and ApJL from 1986 to 1994. Altogether, there are now over 200,000 references in the system.

Full journal article access

A major addition to the ASIAS, completed in January, is the article service. This service provides online access to full journal articles. Currently, the ApJLs from 1975 to 1994 are online, with plans to bring the ApJ and the *Astronomical Journal* (AJ) online as well within the next few months. These journals will be made available one year after publication. Copyright issues are currently being discussed with other journals. These other journals will be brought online if the necessary permissions can be obtained.

Image storage

The article service also provides access to images of published journal articles. Each page of an article was scanned from the journal and is available in different resolutions and formats for viewing on screen, printing, or storing on local disk. These formats and resolutions are:

- a GIF file at 75 dpi (dots per inch) resolution for each page
- a Postscript Level 1 file in Unix compressed form at 150 dpi resolution for the complete article
- a TIFF g4 compressed file at 150 dpi resolution for each page
- a Postscript Level 2 file at 150 dpi resolution for each page
- a TIFF g4 compressed file at 300 dpi resolution for each page
- a Postscript Level 2 file at 300 dpi resolution for each page

The GIF file is small enough (typically 40 kbytes) to load into a World Wide Web (WWW) browser in a few seconds. It is suitable for reading online. The higher resolution versions are generally for printing. Most browsers will handle the transfer, decompression (if necessary) and printing automatically. Just clicking on the retrieve button should send the file to the printer without any other user intervention.

The 150 dpi version in printed form is good quality. It is comparable to a good quality fax. The 150 dpi Postscript Level 1 file is for older printers that don't understand the newer Level 2 compression. It is longer than the Level 2 version and is therefore stored in compressed form. It contains the complete article in one file. The 150 dpi Postscript Level 2 files are fairly small (~50 kbytes) and print fast (as fast as the printer hardware allows). The 300 dpi Postscript Level 2 files are twice as large and take a few seconds to print per page. All the Postscript versions can be sent directly to the printer, saved on local disk, or viewed with a Postscript viewer. In general, the WWW browser will handle all this automatically.

The Postscript Level 2 versions are stored on the server in TIFF g4 compressed files. The

Figure 1. ASIAS abstract with full article images links with selections for viewing and printing

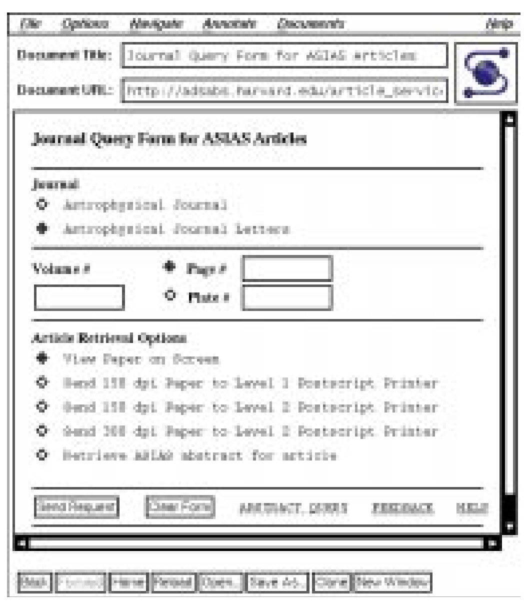

Figure 2. Article query form for direct access to articles in a specific journal, volume and page, with selections for viewing and printing

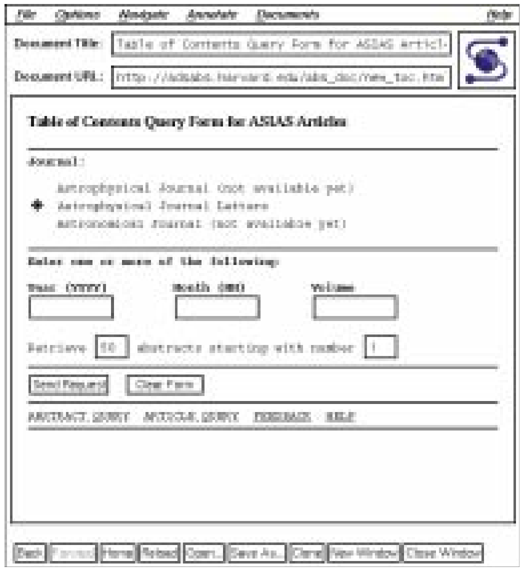

Figure 3. Query form for the table of contents of a specific journal issue by publication year and month with selections for viewing and printing

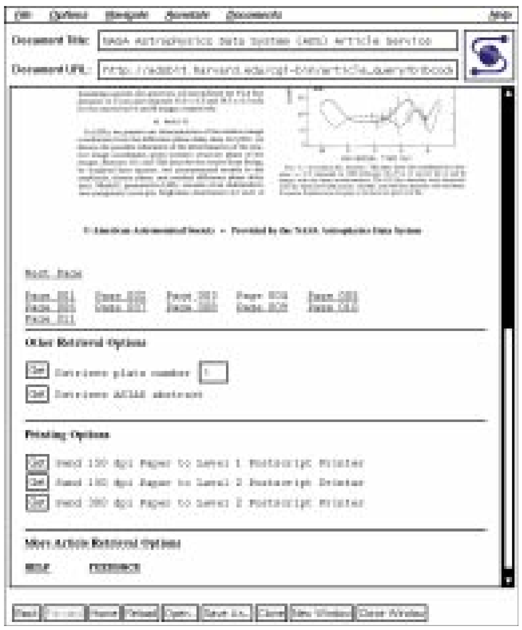

Figure 4. Lower screen section view of an article page with links to other pages of the same article and to the printing options

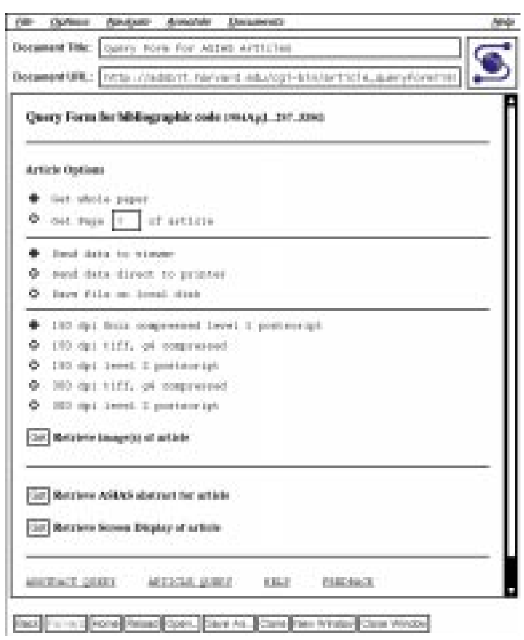

Figure 5. Article images form with detailed retrieval options

Postscript version is generated for each request. This overhead is small compared with the time it takes to transfer the files. The TIFF files can also be retrieved and stored on local disk or viewed on screen. This set of versions provides the maximum flexibility for users with different equipment, printing, or viewing capabilities.

Article query forms

The article images can be accessed from different forms:

1. Every time an abstract is selected from the ASIAS that has the full article images associated with it, the links to the images are included in the returned abstract (see Figure 1). This provides the capability to either view the images on screen or to print the article at different resolutions.
2. Articles can be selected by specifying the journal, volume, and page of a reference (see Figure 2). This allows easy access to bibliographic references published in other articles.
3. A table of contents can be retrieved by specifying the journal and the publication year and month (see Figure 3). From the retrieved list, you can select abstracts with the article links and access the articles as in step 1.

These different forms have only the options to view the GIF images on screen and to print the complete article. These forms also include a link to another form that provides more retrieval options (see Figure 4). This retrieval form allows the user to retrieve the complete article or each page separately. It also provides options for selecting where to send data; to a viewer, to the printer, or to be stored on local disk. It also lets you select which version to retrieve (Postscript Level 1 or 2, or TIFF).

Future developments

The main efforts in the near future are to increase the abstract database and make it as current as possible, and to increase the coverage in the article service.

To achieve the increase in the abstract database there are plans to include more author abstracts from different sources. Abstracts from any source can be included, as long as they are in the ASIAS format. Contributions from anybody are welcomed. There are also plans to include other categories of abstracts in the database (mainly space instrumentation, space engineering, and similar topics).

To achieve increased coverage in the article service, negotiations are being made with different journals to obtain permission to image their journals and to bring them online. Permission has already been obtained from the American Astronomical Society to make their journals available, and permission from other journals may soon be obtained as well. Again, contributions from other journals are welcomed; with permission from the copyright holder and copies of the journal to be scanned. In certain cases, subscriptions to such journals can be started to keep the database up-to-date after the back issues have been scanned.

Access information

Abstracts and articles can be accessed directly from other WWW documents. Access to the ADS abstract service is at:

http://adsabs.harvard.edu/abstract_service.html

For more information on direct access contact the author via e-mail:

gei@cfa.harvard.edu

The ASIAS in the ADS has been restructured following major changes in the budget. The entire ASIAS team is now at the Smithsonian Astrophysical Observatory in Cambridge, Mass.

Automating Archiving at the Center for Astronomical Data at Strasbourg

Nancy Roman, Hughes STX Corp., Goddard Space Flight Center

The Centre des Donnes astronomique de Strasbourg (CDS), France, is the father of a small network of like data centers, including the Astronomical Data Center (ADC), which is part of the National Space Science Data Center (NSSDC) at Goddard Space Flight Center. The CDS has developed a numbering system, used by all of the astronomical data centers, to ensure that a catalog has the same designation in each center. The ADC and the CDS are attempting to set up mirror archives so that each will serve as a backup to the other. Catalogs obtained by either center are made available to the other once they have been prepared for archiving. A data center in Japan will probably also provide a duplicate archive.

Automating catalog archival

The CDS has developed a series of programs and procedures for automating many of the steps required to acquire, prepare, and archive catalogs. The ADC is taking advantage of some of these CDS programs but has not adapted the entire technique because the relation of the ADC with the NSSDC archiving system constrains it to some extent. Also, the ADC staff must familiarize itself more fully with the CDS system. There are still some important steps in the system requiring the participation of a scientist familiar with the field. However, while the CDS procedures limit nontechnical activities, they also assure a high quality archive with adequate documentation for each file.

How CDS obtains its catalogs

The CDS obtains catalogs in a variety of ways. They are:

- The librarians at the Observatory in Paris regularly scan all of the publications they receive for appropriate entries in the Set of Identification, Measurements, and Bibliography for Astronomical Data database. At the same time they alert the CDS to the existence of lengthy and/or potentially useful catalogs.
- By an arrangement with the publishers of *Astronomy and Astrophysics* and *Astrophysics Supplements*, the primary European astronomical journals, the CDS receives the tables from these journals in electronic form. CDS also receives the abstracts of all published papers from the publishers of *Astronomy and Astrophysics Abstracts* (Springer-Verlag) and *Les Editions de Physique.*

- Astronomers at the Observatory in Strasbourg scan all literature for files not otherwise noted.
- Astronomers voluntarily submit files and catalogs for archiving.
- Catalogs are exchanged with other data centers.

For the catalogs identified in the above groups the author is requested to submit files for archiving. Presently, the first two procedures are not used in the United States. However, discussions have begun with the American Astronomical Society (AAS) to receive advance information on files that will appear in their CD-ROM series. The ADC has already received permission to archive these files after they have appeared. In the future, this series will also contain files from at least two other important U. S. journals, the Astronomical *Society of the Pacific* and *Icarus*, as well as from four journals published by the AAS.

The CDS has developed a series of programs and procedures for automating many of the steps required to acquire, prepare, and archive catalogs.

Preparing catalog files

For each catalog the CDS prepares a number of files in addition to one or more data files. These include the following:

- .Summary or .status - a brief description of the contents of the catalog, the reference, and its availability. This is in LaTeX and is designed as a published announcement.
- .history - as its name implies, this is a record of all activity concerning the catalog, including the date for each action and any errors that have been discovered.
- .files - a list of the files that comprise the catalog, their format, and their location.
- .copies - a record of the copies of the catalog that have been made, including the date and the form.
- ReadMe - the document that describe the catalog.

There are sometimes two additional files:

- =obsolete= for catalogs that have been superseded.
- =NOT READY= for catalogs still being worked on.

The format of the ReadMe file is important because much of the automation depends on this form. By using the same format, the ADC is able to employ a powerful program written by CDS to check both that the documentation is adequate and correct and that the catalog does not have misplaced or incorrect characters. For example, the program will alert the user to the existence of positions that contain time expressed as hours and 60 minutes or minutes and 60 seconds; a common problem when positions are precessed from those at another equinox.

When a catalog is received, it is assigned a number according to the standard nomenclature. The program “newcat” creates a directory for the catalog and the skeletons of the files and templates that must be filled in to describe the catalog. The information in these is then distributed to the appropriate files by other programs. The .history file is also begun. The catalog is examined to be sure that it is readable and that the necessary information is available. If not, the author is contacted for supplementary information.

At this point the manual work requiring scientific expertise is begun. The ReadMe file is edited as necessary to ensure that it follows the proper format and “anafile” is used to test both the format of this file and that of the data files. Although the testing is mechanical, the problems that often arise must be resolved by an expert, sometimes with the assistance of the author. There are small programs to prepare common parts of the format tables and to put the format tables in a standard form.

If the new catalog supersedes a previous one, the program “modcat” removes the earlier one from the list of available catalogs, marks it obsolete, and records the number of the catalog that replaces it. Other programs modify the parameters, describing the files of a catalog that has been modified rather than replaced, and correct the .history and .Summary files appropriately.

Most files are now retrieved electronically, but if a file must be copied onto another medium, a program, with the appropriate options entered, makes the copy and updates the .copies file appropriately.

There is still substantial human intervention in preparing catalogs for archiving, but the CDS has made the process easier and efficient.

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Acknowledgements

This summary is based on Gestion des Catalogues *by Francois Ochsenbein of the CDS. The author thanks him for the document, the many discussions, and for his review of this article.*

Space Physics Data System Meeting at UCLA

Robert McGuire, Project Coordinator, Goddard Space Flight Center, Robert L. McPherron, Project Scientist, IGPP/UCLA, and Jim B. Willett, MO&DA Manager, Space Physics Division, NASA Headquarters

A meeting of the Space Physics Data System (SPDS) Coordination Working Group (CWG) was hosted by the SPDS Project Scientist Robert McPherron on February 6-8, 1995, at UCLA. This was the third meeting of this group since the SPDS Rice Workshop in June 1993 and the selection of members of the CWG in late 1993. The organization and goals of SPDS have been discussed in earlier issues of this newsletter.

The SPDS umbrella

Although operating with very limited funding, there is a growing collection of data and services under the umbrella of SPDS. Of key community benefit should be the range of data restoration and data accessibility work now ongoing or likely to commence in the fairly near future, including:

- digitization of analog plasma wave data from multiple instruments
- several magnetometer and plasma data collections
- major collections of data from Scatha and S3-3
- digitization of ISIS topside sounder analog data
- SOLRAD and SKYLAB data
- cosmic ray data from ISEE-3
- neutron monitor data
- laboratory data on cross-sections and other data from various sources including AE, DE 1/2, ISEE 1/2, ATS 5/6 and CRRES

A more complete and detailed list of specific projects will appear in a subsequent issue of this newsletter, as well as other information distribution media.

Key topics

Key topics discussed at the February 1995 meeting include:

- progress on efforts in data restoration and improved data accessibility now being funded by the Space Physics Division MO&DA program under the general heading of SPDS support
- a shift in emphasis towards data accessibility in FY1996 efforts of the SPDS, with an informal call for white papers from the community to identify new ideas for specific data activities, to be made within the next several months
- policy areas to be addressed in developing a draft Discipline Data Management Plan for the Space Physics Division and general principles to apply e.gg. in the quality, completeness, and timeliness of data archival and public data access by major missions
- specific issues and concerns in the current International Solar Terrestrial Physics (ISTP) draft Project Data Management Plan
- discussion of the appropriate role and relevant services of the Space Science Data Center to the evolving system architecture and focus of SPDS
- reports from each of the Discipline Coordinators on team activities and concerns, plus a report from the project coordinator on changes and improvements to general SPDS access via World wide Web (WWW) since the last meeting (including new pages on meetings, software of space physics interest, and major restructuring of the pages on services and SPDS coordinators).

These reports were followed by a range of general discussions. Three of the four discipline teams plan meetings within the next six months (detailed information on these meeting and their results to be made available via the WWW pages of SPDS). All teams expect to be, or are already, working on assuming primary responsibility for discipline-specific WWW home pages on relevant services. It was also noted that the Space Physics Division at NASA Headquarters now has a WWW home page that has been made accessible from the SPDS WWW pages.

Access to services and data

Access to SPDS services and data may be gained from the SPDS Home Page on the WWW at URL:

http://nssdca.gsfc.nasa.gov/spds/spds.html

or via a no-password guest account (name SPDS) to both character and X-windows based users. You may connect via NSI/DECnet "set host nssdca" or via Internet telnet:

nssdca.gsfc.nasa.gov

These pages include a current and complete list of the SPDS coordinators, project scientist and discipline team members with addresses, telephone, and e-mail contact information. Names, affiliations and e-mail addresses of the coordinators were also included in the last article on SPDS in this newsletter.

The next meeting of the SPDS CWG is tentatively planned for early October 1995. Planned meetings of the SPDS teams are now listed on the SPDS meetings page under WWW.

Comments to existing SPDS services and new ideas from the community to any/all of the coordinators are highly encouraged. A poster paper on SPDS services and activities with demonstrations and handouts is planned for presentation at the special session on Space Weather during the Spring 1995 AGU meeting in Baltimore.

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Astrophysicists Create Supernova in a Supercomputer

Jarrett Cohen, Science Writer, Goddard Space Flight Center

The author interviewed Goddard astrophysicist Bruce Fryxell following the January meeting of the American Astronomical Society — Editor's note.

Goddard astrophysicist Bruce Fryxell, working with colleagues from the University of Arizona (UA), has developed a supercomputer model that confirms recent observational evidence for why a supernova occurs.

The best understood type of supernova is a massive star (eight or more times the mass of our sun) that, after exhausting its nuclear fuel, collapses its core into a hyper-dense ball and then ejects its shell in a brilliant explosion. Likely the most violent phenomenon in the universe, for a short time the supernova outshines an entire galaxy.

These latest two-dimensional calculations point to a decisive role for neutrinos-subatomic, massless (or nearly massless, as some recent experiments support) particles of neutral charge in causing this stellar eruption. The work is a collaboration between Fryxell of the High Performance Computing Branch at George Mason University, and Adam Burrows and John Hayes of UA's Departments of Physics and Astronomy.

As a star evolves

A newly formed star burns hydrogen in its core. As the star evolves, its core is converted to elements higher on the Periodic Table, reaching iron just before a supernova. "Burning all the elements up to iron releases energy, but no energy can be released by burning iron," said Fryxell. At this stage "... the core can't create any pressure support for the star, and the core collapses very rapidly, in about 200 milliseconds."

This collapse forms a neutron star that, after cooling, is extremely dense. "It is like having the mass of the sun in an area the size of a city," Fryxell said. As the core becomes stiffer and stiffer, it reaches the point where it cannot be further compressed. "When that happens, a shock forms, quickly spreads out from the center, and ejects the envelope, creating the magnificent display that we see," he explained.

Supernova models

Previous supernova models, which were one-dimensional, produced explosions but were later found to have incomplete physics. When the correct physics was added, the simulations did not explode. As the shock wave moves through the iron core, it gives its energy to the iron and converts it to helium. In the older models, this energy transfer stalled the shock and the envelope was not ejected. Because the core collapsed quickly and the outer layers just rained upon it, a black hole resulted.

The new two-dimensional model shows that earlier efforts failed because they could not take all the multidimensional effects into account. During neutron star formation, protons and electrons combine into neutrons, releasing a neutrino after each merger. With the neutrinos comes a tremendous amount of energy (1053 ergs), which would take our sun 793 billion years to produce. The new model discovered that this energy surge drives a process called convection, or uneven heating, which Fryxell likened to boiling water.

"The convective motions carry the neutrinos further out in the core, where lower density allows them to be released. This process results in an increased rate of energy release," Fryxell said. "When the neutrinos come out and heat up the thin [surrounding] layer, it becomes unstable."

"In the one-dimensional models . . . [w]hen that matter gets too hot, it cools by neutrino emission," he stated. "As a result, the energy (from the neutrinos) that could be used to revitalize the shock is wasted."

In two dimensions, "... the matter rises out of the neutrino heating before it gets too hot, so it doesn't get hot enough that it starts cooling by neutrino emission," Fryxell said. With more of the matter heated between the core and the shock, more energy can be deposited in the region before the cooling starts getting rid of it again. "Because you have more energy dumped in that area, you have enough pressure to energize the shock and cause it to start moving out again," he added.

These findings agree with neutrino detections after Supernova 1987A. As neutrinos pass through ordinary matter relatively easily, detectors are far underground to avoid interference with all the other particles that hit the Earth's crust. The detectors found a total of 17 neutrinos, which is consistent with the expected number, time scale of release, and energy. Despite such evidence, Fryxell said there is much about physics that nobody understands.

Computer power limits modeling

Computer power also limits the extent to which supernovae can be modeled. With the current understanding, the Goddard-UA model required 50 trillion floating point operations and over 200 hours on one processor of the Pittsburgh Supercomputing Center's CRAY C90. A CRAY C90 processor has a peak speed of 1 billion floating point operations per second, expressed as a gigaFLOPS.

Fryxell pointed to several weaknesses in the model, including:

- crude simulations of neutrino transport that allow them to move only in radial directions
- an imprecise equation for determining compressibility
- lack of star rotation

According to Fryxell teraFLOPS (tera = trillion) computing, expected in the next few years, is needed to add these effects. Doing such calculations in three dimensions would require another thousand-fold leap to petaFLOPS, which will perhaps be available in 20 years.

"What I would really like to do is start the star from an initial gas cloud, evolve it through its entire lifetime and onto supernova," Fryxell said.

"That is way beyond petaFLOPS!"

For further information contact the author via phone: 301-286-2744 or e-mail:

jcohen@jacks.gsfc.nasa.gov

Color figures and an MPEG-format movie are available on the World Wide Web at:

http://lepton.physics.arizona.edu:8000/graphics.html

Another team made up of UA and Los Alamos National Laboratory researchers reported similar conclusions from a different set of calculations.

Information Management System Prototype and Distributed Active Archive Centers Provide Ready Access to Data

Susan Digby, Jet Propulsion Laboratory, Greg Hunolt and the EOSDIS User Services Working Group, Goddard Space Flight Center

Physical Oceanography DAAC
Distributed Active Archive Center
JET PROPULSION LABORATORY

PO.DAAC

Physical Oceanography Distributed Active Archive Center

The Physical Oceanography Distributed Active Archive Center (PO.DAAC) at the Jet Propulsion Laboratory contains satellite data sets and ancillary in-situ data for the ocean sciences and global-change research to facilitate multidisciplinary use of satellite ocean data. PO.DAAC is an element of the Earth Observing System Data and Information System (EOSDIS) and the U.S. distribution site for TOPEX/ POSEIDON data and metadata.

The Earth Observing System Data and Information System (EOSDIS) provides a structure for managing data and provides users with ready access to data and derived products from EOS satellite instruments slated for launch over the next two decades. Within the EOSDIS framework, the Distributed Active Archive Centers (DAACs) are responsible for providing data and information services to support the global change research community.

Although much of the development within EOSDIS has been in anticipation of the future launch of the EOS instruments, each of the nine DAACs now has significant data holdings. These holdings can be searched and ordered via the Version 0 Information Management System (V0 IMS) prototype. Data can also be ordered via e-mail, fax, phone mail, through the World Wide Web (WWW) using a browser such as Mosaic, and via heritage order systems that predate EOSDIS.

Archive centers

There are currently nine DAACs responsible for data archival, product development, distribution, and user support. The DAACs are distinguished from one another by data-subject area and hold pre-EOS data that can be used to address global change issues. Since the inception of EOSDIS, the DAACs have worked to provide a consistent and high level of service to support the concept of a single, but distributed system, of which the V0 IMS prototype is a major part. Electronically linked by the V0 IMS prototype, which was released in August 1994, DAACs appear to users as a single system. You can search for and order data from any or all of them, and can contact the User Services staff at any DAAC to obtain assistance in using the IMS or to find out more about a particular data product.

In addition to the capabilities provided by the V0 IMS prototype, some DAACs have individual online systems, allowing them to provide unique services to users of a particular type of data. These “DAAC-unique” systems look and function much like the V0 IMS prototype, but emphasize products or services specific to that DAAC.

Cooperating data centers

In addition to the EOSDIS DAACs, there are a number of different agencies and data centers cooperating within the Mission To Planet Earth framework to make data more accessible. One example of this cooperation within EOSDIS is the Satellite Active Archive (SAA) developed by the National Oceanic and Atmospheric Administration (NOAA) which is searchable using the V0 IMS prototype. The DAACs also have close ties with other NOAA archives but these have yet to be manifested through the V0 IMS prototype.

The role of the V0 IMS prototype

The development of the V0 IMS prototype is seen as an important step towards the realization of interdisciplinary Earth science research. Historically it has been difficult for scientists conducting interdisciplinary research to locate useful data because it was necessary to contact many different data centers regarding data holdings and availability. The V0 IMS is a prototype system designed to overcome that difficulty by allowing you to search for and order data from any DAAC, or combination of DAACs, in a single online session. With this system, researchers have the ability to search for data based on a number of criteria that include time, space, geophysical parameter, sensor, and instrument. Beyond the ability to search for interdisciplinary data, features of the V0 IMS prototype that are especially useful to the science community are: the ability to visualize the extent of available data on a globe that can be rotated and the ability to retrieve browse images that can be used to assess the product usefulness prior to ordering.

Metadata have also been addressed; the V0 IMS prototype is linked to the Global Change Master Directory (GCMD) such that the Directory Interchange Formats, which describe a product, are accessible. In addition, to support the V0 IMS prototype, online documents that provide detailed and comprehensive information about the data products are being produced. Known as Guides, they represent a further step in ensuring the high quality and usability of data.

There has also been a strong emphasis on providing data in a common format so that data from different sources can be readily compared. EOSDIS has selected the Hierarchical Data Format (HDF), a format that has been developed by the National Center for Supercomputing Applications (NCSA). NCSA has also developed software to work with HDF. Development of both HDF and associated software is ongoing.

V0 IMS prototype functionality

The following list of V0 IMS prototype functions provides an overview of the utility of the system:

- Directory - provides high level information about V0 IMS data sets by linking to data set information held within the GCMD.
- Guide - provides detailed descriptions about data sets, platforms, sensors, and data centers.
- Inventory - provides descriptions of individual observations or data items (granules) that can be ordered from a DAAC; in some cases individually, otherwise as part of a product.
- Coverage Maps - shows the geographical coverage of user-selected inventory granules.
- Browse - displays images as an aid to data selection, which is particularly useful for images where cloud cover is an issue (browse images may be staged for FTP pickup or viewed in the graphical interface).
- Product Request - allows you to select preferences, such as processing options and media types available for the data product, and then submit a request that is forwarded to the appropriate DAAC.
- GCMD Access - provides a link to the GCMD, which is a multidisciplinary and international database of information about Earth and space science data . You may search this database for data not available through the V0 IMS prototype.

Accessing the V0 IMS prototype

The Version 0 IMS prototype offers both a Graphical User Interface (GUI) and a Character User Interface (ChUI). Running the GUI requires a workstation, X terminal, or PC/Macintosh capable of running the X Windows System (or an X terminal emulator such as MacX), with a 1024x768 pixel color display. System response time for the V0 IMS GUI will be limited by the capacity of the network connection between your user site and the DAAC that you access. Generally a communications capacity of 56 kbps is needed for good performance. The ChUI requires less communications bandwidth and thus performs better where network capacity is limited. Running the ChUI requires a PC/Macintosh using a VT100 emulator or any VT100 compatible terminal.

You may access the V0 IMS prototype from the WWW V0 IMS Home Page by selecting “Access to the EOSDIS V0 IMS.” The Home Page also provides additional information, such as an online user’s manual and tips for usage and user terminal configuration. The Home Page URL is:

http://harp.gsfc.nasa.gov:1729/
eosdis_documents /eosdis_home.html

V0 IMS prototype evaluation

As would be expected with a prototype, you will encounter some rough edges, both in terms of minor problems with the system and with performance. Information gained from user experience with this prototype will be used in the development of future search and order systems. Comments on this system are welcome and can be provided online or through the User Services offices at the individual DAACs.

Archives and discipline areas

The DAACs and the SAA are listed below with their subject areas, contact information, and V0 IMS telnet access.

- ASF DAAC - SAR & Polar Regions
  Voice: 907-474-6166
  Fax: 907-474-5195
  Internet: asf@eos.nasa.gov
  WWW URL:http://eosims.asf.alaska.edu:12355/asf_homepage.html
  V0 IMS prototype telnet access: eosims.asf.alaska.edu 12345

- EDC DAAC - Land Processes
  Voice: 605-594-6116
  Fax: 605-594-6589
  Internet: edc@eos.nasa.gov
  WWW URL: http://sun1.cr.usgs.gov/landdaac/landdaac.html
  V0 IMS prototype telnet access: eosims.cr.usgs.gov 12345

- GSFC DAAC - Upper Atmosphere, Global Biosphere
  Voice: 301-286-3209
  Fax: 301-286-1775
  Internet: gsfc@eos.nasa.gov
  WWW URL: http://daac.gsfc.nasa.gov
  V0 IMS prototype telnet access: eosims.gsfc.nasa.gov 12345

- JPL DAAC - Physical Oceanography
  Voice: 818-354-9890
  Fax: 818-393-2718
  Internet: jpl@eos.nasa.gov
  WWW URL: http://podaac-www.jpl.nasa.gov
  V0 IMS prototype telnet access: eosims.jpl.nasa.gov 12345

- LaRC DAAC - Radiation Budget, Tropospheric Chemistry
  Voice: 804-864-8656
  Fax: 804-864-8807
  Internet: larc@eos.nasa.gov
  WWW URL: http://eosdis.larc.nasa.gov
  V0 IMS prototype telnet access: eosims.larc.nasa.gov 12345

- MSFC DAAC - Hydrologic Cycle
  Voice: 205-922-5932
  Fax: 205-922-5859
  Internet: msfc@eos.nasa.gov
  WWW URL: http://wwwdaac.msfc.nasa.gov/
  V0 IMS prototype telnet access: eosims.msfc.nasa.gov 12345

- NSIDC DAAC - Snow and Ice, Cryosphere and Climate
  Voice: 303-492-6199
  Fax: 303-492-2468 Internet: nsidc@eos.nasa.gov
  WWW URL:http://eosims.colorado.edu:1733
  V0 IMS prototype telnet access: eosims.colorado.edu 12345

- ORNL DAAC - Biogeochemical Dynamics
  Voice: 615-241-3952
  Fax: 615-574-4665
  Internet: ornl@eos.nasa.gov
  WWW URL: http://www-eosdis.ornl.gov/
  V0 IMS prototype telnet access: eosims.esd.ornl.gov 12345

- SEDAC - Human Impact on Global Change
  Voice: 517-797-2727
  Fax: 517-797-2622
  Internet: sedac@eos.nasa.gov
  WWW URL: http://www.ciesin.org
  V0 IMS prototype telnet access:

- NOAA SAA - Satellite Earth Sciences Data
  Voice: 301 763-8400
  Fax: 301 763-8443
  Internet: sdsdreq@ncdc.noaa.gov
  WWW URL: http://ns.noaa.gov/saa homepage.html
  V0 IMS prototype telnet access: eosims.saa.noaa.gov 12345

For further information, contact Susan Digby via phone: 818-354-0151 or e-mail: ssd@shrimp.jpl.nasa.gov

Animating Observation Geometries with Amphion

Steven Roach, University of Wyoming/Ames summer graduate student, Michael Lowry and Thomas Pressburger, Amphion Project, IC Division, Ames Research Center

Navigation Ancillary Information Facility

The goal of the Navigation and Ancillary Information Facility is to provide the planetary science community with data sets and transportable software tools, appropriate for computing, archiving, accessing and distributing the ancillary viewing geometry needed to interpret observations of solar system bodies.

Science opportunity visualizers (SOVs) are essential tools for analyzing mission designs, planning detailed science observations, and aiding the analysis of science data returned from a spacecraft's instruments. In the past, creating an SOV was a labor intensive software development process. This article describes an extension to the Amphion automatic programming system that facilitates the rapid generation of SOVs for understanding observation geometries. Although this extension is not yet mature, it has already been employed in developing a SOV that is actively being used by the planetary rings community, as well as dozens of prototype animation programs.

This article first reviews SPICE and Amphion, and then discusses the extensions that are used in generating SOVs.

SPICE and Amphion

Jet Propulsion Laboratory' s (JPL) Navigation and Ancillary Information Facility (NAIF) Group constructed the SPICE ancillary information system to assist in planning observations and interpreting data from space borne instruments. It includes data sets for solar system bodies (e.g., planets, satellites, and spacecraft) and software in the form of a FORTRAN-77 subroutine library. The subroutines can be used to write programs that, by accessing SPICE data sets, calculate observation geometry parameters. A recent overview of SPICE was presented in the December 1994 issue of this newsletter on pp. 29-30.

Amphion is an automatic program synthesis system; that is, a system that writes source code programs given high-level problem specifications. Amphion was introduced in the February 1994 issue, pp. 22-25. It consists of a graphical user interface and a program synthesis subsystem. Amphion allows you to program at the level of abstract problem specifications instead of at the tedious level of programming language syntax. It is a general program synthesis system that is tailored to a particular domain by a

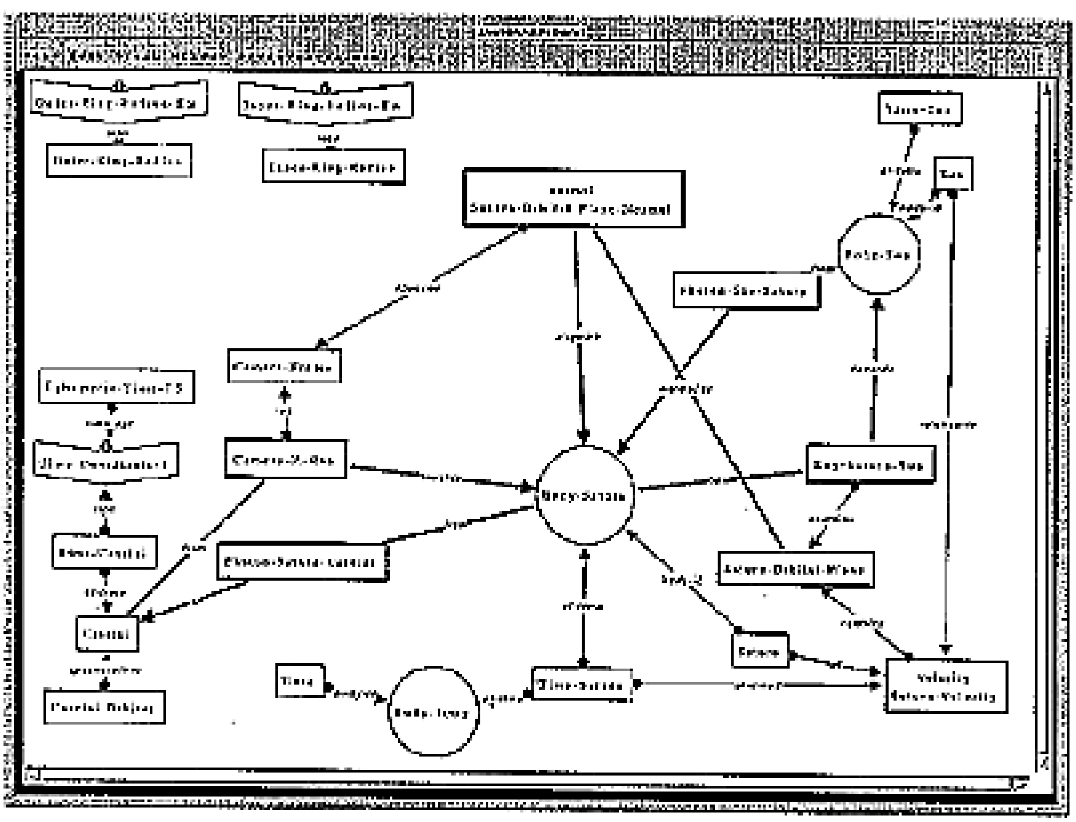

Figure 1. Graphical specification of Cassini observation geometry

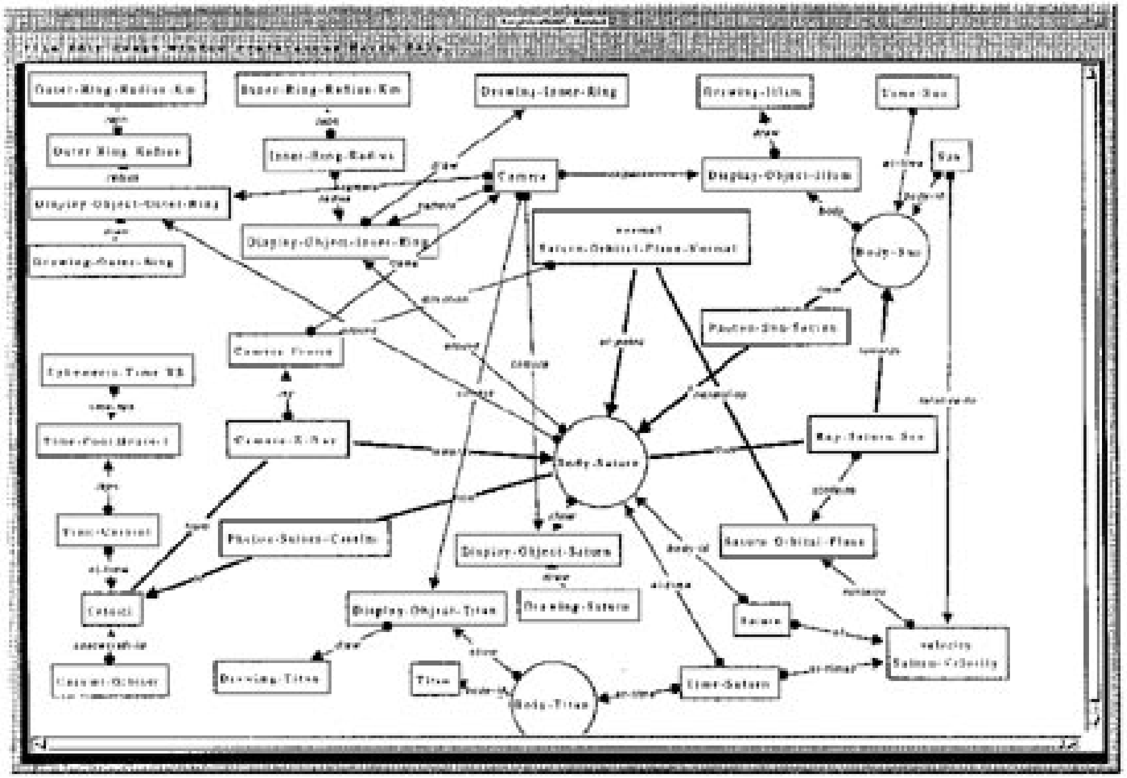

Figure2. Figure 1 augmented to specify a visualization

domain theory. The first theory written for Amphion was for the SPICE domain. Using this theory, Amphion generates FORTRAN programs containing calls to SPICE subroutines.

With Amphion, you do not need to be familiar with the hundreds of SPICE subroutines or the data structures they require. The graphical user interface guides you in the creation of a specification diagram (see Figures 1 and 2). The program synthesis subsystem then generates a FORTRAN program. In preliminary testing, SPICE programmers were able to generate graphical specifications with less than an hour of training. SPICE programmers can typically generate correct programs much faster using Amphion than on their own.

Observation geometry visualization

Amphion is designed to be easily extensible, so that as NAIF adds new functionality to the SPICE system, Amphion can be augmented to generate programs calling new SPICE components. For the work described in this article, the NAIF domain theory was augmented to support the specification of visualizations and the generation of programs containing calls to graphics subroutines. To specify a visualization, an Amphion user specifies an observation geometry, adds the specification for a camera, and then specifies the bodies and illumination sources for the visualization. The camera defines the location from which the scene is observed. For example, in Figure 2, the camera is located at the Cassini spacecraft and the boresight points toward Saturn.

The basis of the animation system is a graphics package called Euclid, developed by Bill Taber of the NAIF group. This package draws visualizations containing points, rings, and wire frame ellipsoidal bodies. Euclid is suitable for visualizing observation geometries, but is not meant for producing photo-realistic images. Euclid uses ray tracing techniques to determine how the rings and bodies are illuminated by one or more specified light sources. Euclid is device independent and uses a simple device driver interface called ESCHER that has been ported to a variety of graphics devices. As part of this project, ESCHER was ported to the Unix X-windows system, the same system used by Amphion's graphical user interface.

Example: Cassini visualization

In 2004, the Cassini spacecraft will begin orbiting Saturn. Cassini will fly by Titan several times during the mission. Figures 1 and 2 show an Amphion specification for a program to visualize Cassini's view during its mission. Figure 1 shows the specification of the observation geometry, and Figure 2 shows the same specification augmented for visualization.

The specification in Figure 1 includes Saturn, Titan, the Sun, and the Cassini spacecraft. In this specification, a “body” is the location of some object at a particular time. So the “Body-Saturn” icon is the location of the planet Saturn at Time-Saturn. The inputs to the program are the time of the observation at Cassini (Time-Cassini) and the inner and outer diameter of one of Saturn’s rings to be displayed. To allow for the time light takes to travel, the time of Body-Saturn is the time a photon would have left Saturn to arrive at Cassini at Time-Cassini. The time of Body-Sun is specified in a similar fashion. Since they are relatively close, we assume that the time of Body-Titan is the same as that of Body-Saturn.

To create a visualization, a camera must also be specified. A camera has a coordinate system called a frame. The z-axis of the frame points along the camera boresight toward the objects being viewed, the x-axis points to the right, and the y-axis points up. In Figure 2, the z-axis is defined as a ray from Cassini toward Body-Saturn. The y-axis is orthogonal to the x-axis and is aligned with the vector normal to the orbital plane. The orbital plane is defined as the plane that contains two vectors: the instantaneous velocity vector of Saturn, and a vector from Saturn to the Sun.

In Figure 2 the specifications have been added for the objects to appear in the visualization and for the location of the source of light. This is done by creating display-objects. Each display-object consists of two components: an object in the specification and the camera from which it is viewed. In Figure 2 there are display-objects for Body-Saturn, Body-Titan, and the inner and outer edges of the ring. Rings are visualized as pairs of simple ellipses depicting the inner and outer edges. The illumination source is Sun-Body.

From the specification in Figure 2 Amphion generates a FORTRAN program containing the appropriate calls to the SPICE and Euclid subroutines. These in turn call ESCHER and X-windows subroutines that open a window on a terminal and display a visualization. The program can automatically generate visualizations for a sequence of times, thus producing an animation. In contrast to many other animation programs, the program is efficient enough to generate the sequence of views in real time. Thus the entire Cassini four year tour is animated at any desired time compression without storing a buffer of images. Figure 3 is a frame from this animation at the time of the first Titan fly-by.

Animation and ring crossing visualizer

A fragment of the Cassini animation was extracted to create an MPEG file at the University of Wyoming. This MPEG file is a time-compressed animation of the first Cassini fly-by of Titan; it is about a minute long. This fragment can be viewed on Amphion’s World

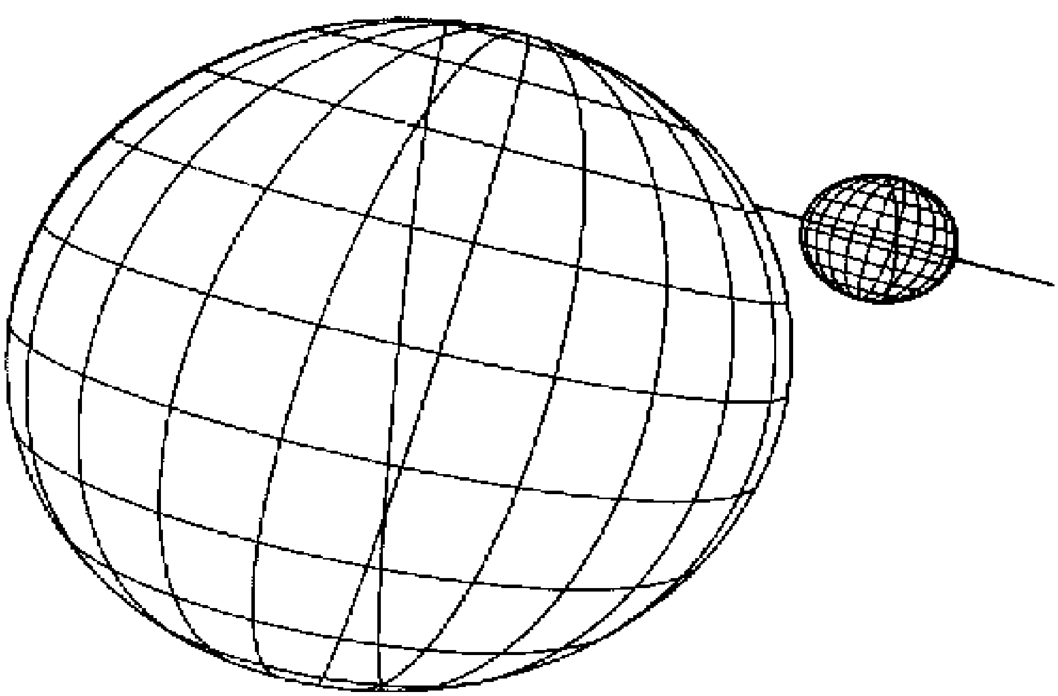

Figure 3. Freeze frame of first Titan fly-by in Cassini tour animation. Animation program was generated by Amphion.

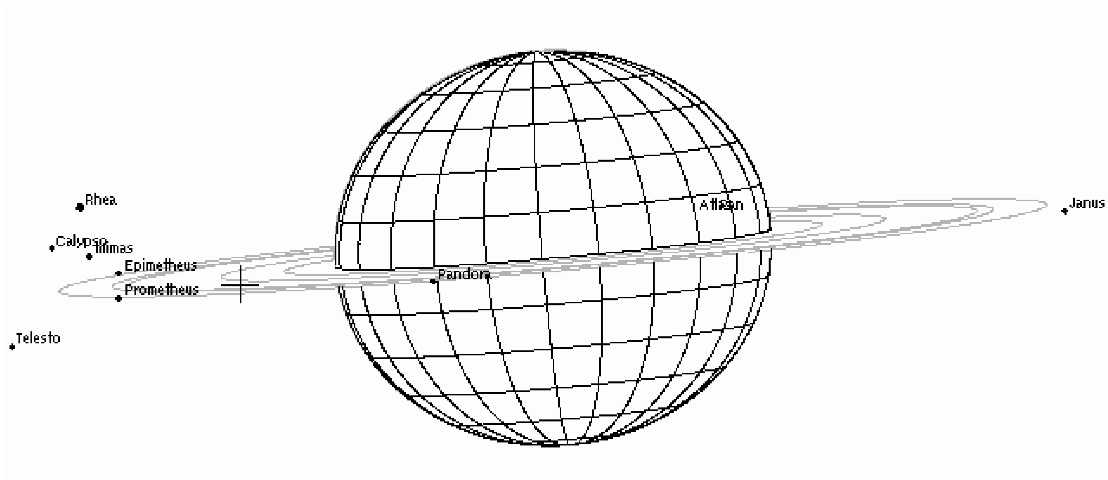

Figure 4. Diagram of Saturn system generated by PDS Rings Node's Saturn Viewer program

Wide Web (WWW) Home Page at:

http://ic-www.arc.nasa.gov/ic/projects/amphion

or downloaded through anonymous ftp from:

ai.uwyo.edu:/pub/nasa/

The animation can be seen through any MPEG viewer, although some MPEG viewers might not display the colors correctly.

In December 1994 Mark Showalter, manager of the Rings Node for PDS, inquired about using Amphion to generate visualizations of the Saturn system as it will appear from Earth during the 1995-96 ring plane crossings. His objective was to provide a Web-based SOV to help astronomers plan their observations. Mark was able to adapt the specification in Figure 2 very quickly to produce a specification for his SOV. The program generated by Amphion was then further modified by Mark and is now accessible through the WWW at:

http://ringside.arc.nasa.gov/www/rpx/rpx.html

Figure 4 was generated using this Saturn Viewer program. It depicts Saturn, its rings, the inner moons, and an occulted background star just a few minutes after the Sun finishes crossing Saturn's ring plane at 12:05 UTC on November 21, 1995. The rings are shown in light gray because we will be seeing their unilluminated side at this time. The locations and names of the inner moons are shown (although the names are printed in a font too small to read in this reproduction). By coincidence, a 12th magnitude background star, shown as a plus, will be occulted by the rings at this time.

Current status of Amphion visualization capabilities

Currently, Amphion generates a visualization subroutine containing calls to SPICE and Euclid subprograms. The user must build the main program that calls this subroutine. Templates of main programs are available, and in practice it has been easy for programmers familiar with FORTRAN to build main programs from the templates. The main program templates have facilities for changing camera parameters at execution time (zoom in and out, pan side to side), and for starting and stopping the animations and stepping forward or backward through time.

Future plans

The Amphion group is working to augment the animation domain theory and driver code to support multiple illumination sources, text, and multiple cameras. We plan to enhance the animation component to make it more compliant with the full features of the X-windows system and to make the execution environment more intuitive.

Amphion is also being extended to generate iterative code that searches for solutions to queries such as "When does a geometric configuration occur in a time interval" and "When does a geometric function take on a minimum value in a time interval." The NAIF group developed a set of iterative FORTRAN drivers call PERCY that form the components for this capability. Amphion is being extended to target PERCY, just as it was extended to target the elements of Euclid. Amphion's PERCY capability has already been prototyped. In combination with the animation capabilities, this will provide a basis for rapidly generating science opportunity analyzers.

For further information contact Michael Lowry via phone: 415- 604-3369 or e-mail:

lowry@ptolemy.arc.nasa.gov

Information Systems Program Highlights

Major accomplishments achieved by NASA's Information Systems Office (Code STI) are highlighted below. They cover work performed from November 1994 through February 1995, and reflect the combined efforts of many people.

Accomplishments

Goddard Space Flight Center

High Performance Computing Branch, HPCC Earth and Space Science (ESS) Project—Jim Fischer

- The ESS Project has developed a strategy to acquire the FY96 ESS/GSFC resident testbed system and the second round of ESS Grand Challenge investigators through a single Cooperative Agreement Notice (CAN) solicitation. The goal is to begin the approval cycle in February, release the CAN in April, select the investigators in September 1995, and place an ESS/GSFC resident testbed system in January 1996. This approach was presented to Headquarters Science Management from Codes S, Y, and U on February 7 and received strong support.

- The ESS Project played a leadership role in the multi-agency Second Pasadena Workshop on System Software and Tools for High Performance Computing Environments held January 10-12, 1995, in Pasadena. The goal of the workshop was to bring together developers, vendors, and users of system software and tools in an open forum.
- The Scientific Visualization Studio (SVS) and the NASA Center for Computational Sciences (NCCS) are now actively utilizing Virtual Reality (VR) technology in an attempt to increase the efficiency of scientific visualization. A modified version of the Flow Analysis Software Toolkit (FAST) software, developed by Sterling Software and NASA/Ames, and a Fakespace Boom 3C have been delivered to GSFC, and the system is operational. FAST performs calculations on and visualizations of large "gridded" 2-D and 3-D data sets. The boom provides stereo, high resolution displays, and a high precision tracking system that allows users to "get inside" the data being analyzed. The Fakespace Boom is one of the most technically superior display and position-tracking VR devices available. It provides two full-color, 1280-by-1024-resolution displays (one for each eye) and rapid, three-dimensional position tracking with an accuracy of .1 degrees (spherical coordinates). The VR-FAST system development was funded by the HPCC Earth and Space Science Project.

Mass Storage and Scientific Computing Branch (MSSCB)—Nancy Palm

- The NASA Center for Computational Sciences (NCCS) and Federal Data with Convex Corp. have agreed to beta test the upcoming release of Convex's UniTree+ 2.0 (RedOak). This new version of the software will allow for multiple parallel tape writes (a vast improvement over current software that allows for only one migration write tape at a time) and a more flexible tape drive configuration capability.
- The Convex/UniTree system is now providing a reliable production capability that delivers 100-200GB in daily traffic. The system currently stores one million files with an average file size of 14MB.

- The number of operator tape mounts has been reduced substantially, largely due to the dramatic increase in robotically controlled silo capacity created by the installation of 36-track, 3490 drives and the use of double-length tapes. Because each cartridge in the robotic STK silos can now hold 800MB, UniTree has not had to vault data to offline (free-standing) tapes. In addition, the movement of data from the IBM/MVS Hierarchy Storage Management (HSM) data archive has subsided. The operator-intensive effort to scan all offline UniTree vault tapes for errors was also completed, further reducing the number of manual tape mounts. Seventy percent of the data archived in the NCCS is accessible by robotic means. The remaining data consists of 1.7 TB of HSM data and 3.1TB of UniTree vaulted data. Most of the data are rarely used backups. The UniTree vaulted data contains files that have not been accessed since June1994. NCCS user data are now handled almost exclusively by robotic servers.

- The export/import facility developed by the NCCS has entered a solid production phase with total data movement of over 70GB in January. In January the import/export facility processed 341 cartridge tapes, 10 miniature tapes, and 6 reel tapes (12,197 MB of data exported; 58,593 MB of data imported).

Computer Networks and Communications Branch (CNCB)—Patrick Gary

- The CNCB continued preparations for conducting high-data-rate communications between GSFC and JPL via the Advanced Communications Technology Satellite. The CNCB successfully installed and conducted initial performance tests of a 800-Mbps High Performance Parallel Interface switch and a 155-Mbps Cray Bus-Based Gateway unit connecting GSFC's Cray C98 supercomputer into a high-speed Asynchronous Transfer Mode (ATM)-based network.
- The Minority University-Space Interdisciplinary Network Project (MU-SPIN) provided a Regional Network Training Workshop at the Navajo Community College (NCC). The NCC is a Native American-serving institution in Shiprock, New Mexico, serving the greater Southwest region. Over 45 workshop attendees came from the NCC's local and remote campuses, San Juan Community College, and other schools in the area's consolidated school district. Many traveled over 100 miles to attend, and the NCC videotaped workshop sessions for future use.

- The CNCB successfully demonstrated parts of the Earth Alert System's base station and pager-like receiver units to State of Hawaii Civil Defense (CD) officials using elements of the CD's warning infrastructure in Hawaii. Full demonstration field tests are scheduled for the spring.

- The CNCB developed designs for extending GSFC's 2.4 Gbps SONET/2x155 Mbps connection with the Application Technology Demonstration Network (ATDNet). This will enable ATM-based access from GSFC's Laboratory of Terrestrial Physics to the EROS Data Center (EDC) via a connection between the ATDNet and the MAGIC gigabit testbed in the midwest, which includes the EDC.

Scientific Applications and Visualization Branch (SAVB)—Horace Mitchell

- The SAVB received Headquarter funding to support its role in the Global Learning and Observations to Benefit the Environment (GLOBE) program. The Scientific Visualization Studio (SVS) is constructing a visualization server that will automatically produce visualizations of the environmental data gathered by students at GLOBE schools and from more traditional sources for use as educational material for students in the GLOBE program.

- The SAVB has produced NCCS Science Highlights-FY94, a compilation of NASA-funded research results in Earth and space sciences performed at the 74 science submissions. The publication is posted on the World Wide Web at:

  http://sdcd.gsfc.nasa.gov/SAVB/SH94

Call (301)-286-1055 (doclib@nccs.gsfc.nasa.gov) to order a copy.

- The SVS produced an animation of lunar topography using data from the Clementine program. The animation depicts the moon being approached from a distance, and then its surface being traversed, showing old craters that were not readily apparent in still images. This video was produced for the Geodynamics Branch/Code 921 and was shown at the Clementine Calibration Meeting in Flagstaff, AZ.

Ames Research Center

NASA Science Internet —Pat Kaspar

- NSI Program Manager Tony Villasenor and four members of the NSI contractor staff attended the Russian Technical Workshop in Tarusa, Russia, (February 15-17) which resulted in the creation of the Russia Internet Exchange (RIX). NSI staff participated in technical discussions regarding the engineering and management of the newly formed RIX. Formal presentations on network security, operations management and applications development were provided by the NSI staff to participants of the workshop.

- The Marsokhod Kilauea project was completed on February 20, 1995. All of the baseline scientific and engineering goals were exceeded and the entire project was a success.

  NSI, in collaboration with National Science Foundation and other U.S. agencies, played a key role in providing the technical expertise and coordination for the "Live From Antarctica" live telecast mini-series which took place on December 13 and 15, 1994, and January 10 and 19, 1995. The January 10th broadcast was marked in history as the first-ever live broadcast from the geographic South Pole. NSI's efforts in this difficult and complicated communications project have been formally recognized in the broadcast credits by Geoff Haines-Stiles Productions and Maryland Public Television.

Jet Propulsion Laboratory

Navigation and Ancillary Information Facility—Chuck Acton

- Much of the work needed to generalize the SPICE Events kernel (EK) subsystem into a portable relational DataBase kernel (DBK) has been completed and tested. A prototype of the DBK is already being used as an interim Clementine image catalog. The DBK is now being considered for use on several other projects needing a cost effective database functionality.

- The NAIF implemented code to facilitate the introduction of new ephemeris (SP-kernel) and spacecraft orientation (C-kernel) data types. This will first be used in support of the NEAR Discovery Project.

- Work has begun on a SPICE tutorial intended to be available as both an HTML document (on World Wide Web) and as a multimedia CD.

- Applied Coherent Technology Corporation has incorporated SPICE kernel access into its PC-based MSHELL image/signal processing system. MSHELL was used to accomplish much of the Clementine image processing.

National Space Science Data Center's Data Restoration Program Winds Down

Joe King, Director, National Space Science Data Center

The National Space Science Data Center (NSSDC) has a fundamental responsibilty to preserve, for future access, the NASA mission data in its archives. To this end, the NSSDC has pursued a data restoration program over the past six years, in which data were migrated from 35,800 aging tapes to 6100 pairs of new 9-track tapes and 3480 tape cartridges. This data restoration program is now concluding in the sense that the NSSDC holds no space science tapes older than 10 years old, except as noted below.

The data restoration program is being followed by data preservation activity, which will be a forever-ongoing activity to migrate data to new media when appropriate. Final judgements are being made now to target media for this activity for the next few years, with CD-Write Once and Digital Linear Tape (DLT) being the most likely choices at this time.

High volume data restoration activity

Of the 35,800 tapes passed through the data restoration program, approximately 19,800 were space science (astrophysics, space physics, planetary) and 16,000 were Earth science (ES). In general, the NSSDC automatically restored all small space science datasets, and enlisted community input in assessing the cost-benefit ratio of restoring large and possibly obsoleted datasets. The following datasets were community recommended for non-restoration. These will be deleted after some advertising (including this article):

- S-Cubed-A, 1878 multi-experiment uncondensed tapes, covering 3/73-9/74. Note that the preceding 1.5 years of this dataset, which had been originally written to less than 300 condensed tapes, has been restored for future accessibility.
- S-Cubed-A, 246 summary plot tapes.
- ATS-1, 55 tapes with data from the suprathermal ion detector.

Additionally, the NSSDC is able to release an additional 3000 old space science tapes as holding differently formatted or organized versions of datasets that have been restored for future access, as holding digital planetary image data now being written to CD-Write Once media at Jet Propulsion Lab, and as holding non-NASA data (mainly geomagnetic), once acquired by the NSSDC for the convenience of Goddard Space Flight Center (GSFC) scientists.

History of the restoration program

The NSSDC's data restoration program started six years ago with a major focus on ES data. About three years ago, the NASA ES program, through the Earth Science Data and Information System (ESDIS) Project Office at GSFC, asserted its responsibility for the disposition of the ES data at the NSSDC. At this time, the NSSDC shifted its data restoration program to space science data. ESDIS, and its associated Earth Observing System Distributed Active Archive Centers (DAACs), are gradually directing the migration of NSSDC-held ES data to appropriate DAACs. A major review of the NSSDC's ES data holdings, coordinated by ESDIS and involving all the DAACs and their science teams, was recently completed. ESDIS judgements on the large number of remaining NSSDC ES datasets are expected to be forthcoming shortly. For any such dataset, the possibilities are:

- designate a DAAC (as has been done for the more in-demand of the NSSDC's ES datasets already)

- migrate to an ES deep archive (most likely the National Oceanographic and Atmospheric Administration for most data)
- release the data (as for the few space science data sets identified above)

During the NSSDC's data restoration program, which operated at an average four-person staffing level, approximately 98% of the data on the 35,800 tapes addressed were successfully migrated to new media. This includes many tapes received at the NSSDC in the 1960s and 1970s, and held in reasonable environmental conditions. In some cases, the NSSDC's backup tapes were used when difficulties were encountered in reading the primary tapes.

A variety of computers was used over the life of the data restoration program, ranging from the NSSDC's now retired Modcomp Classic, a PC-based system, a micro-VAX system (NSSDCs current Media Replication System), and large IBM mainframes (3081, 9021) operated by GSFC's NASA Center for Computational Sciences. A significant hardware and software challenge was keeping 7-track tape reading capability across these platforms.

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Departure

Thank you to everyone for making my 10 years as editor of this newsletter such a positive learning experience. I've accepted a position at the Ames Research Center as manager of the NASA K–12 Support Center. I've thoroughly enjoyed working with all of you, and I hope that our paths will continue to cross in the future.

The newsletter is now in the very capable and experienced hands of Sandi Beck at the Jet Propulsion Laboratory. Please continue to provide her with the excellent contributions and support that you gave me.

I am grateful to have had the opportunity to work with all of you for so long.

Sandy Dueck

NASA Group Achievement Award Presented for Education CD-ROM

The NASA Group Achievement Award was presented to the Planetary Data System (PDS) Education CD-ROM Team for their design and implementation of the educational CD-ROM, *Welcome to the Planets.* The PDS, in collaboration with the Data Distribution Laboratory, developed a tour of the solar system on CD-ROM that is a multimedia education tool including images, sound, and captions covering spacecraft, target bodies, and target features.

Welcome to the Planets has been prepared for education levels grade 9 and above. The Intemational Standards Organization-9660-conforming discs will be distributed to a wide audience for use on multiple computing platforms. A networked version of the contents of this CD-ROM is also available on the World Wide Web at URL:

http://stardust.jpl.nasa.gov/planets

All data and presentations on the CD-ROM have been carefully peer reviewed by prominent scientists to ensure accuracy. Design and production of this CD-ROM were coordinated efforts between PDS teams at JPL and Washington University, with support from the JPL Public Information Office.

Readers are invited to submit special honors or awards received for group or individual achievement in work performed for the Information Systems Branch to Sandi Beck at sandi_beck@iplmail.jpl.nasa.gov for inclusion in this publication—Editor's note.